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| 1881 | contained | 28 | different | adv'ts. | 1889 | " | 234 | " | " |
| 1882 | " | 45 | " | " | 1890 | " | 289 | " | " |
| 1883 | " | 63 | " | " | 1891 | " | 325 | " | " |
| 1884 | " | 82 | " | " | 1892 | " | 316 | " | " |
| 1885 | " | 100 | " | " | 1893 | " | 317 | " | " |
| 1886 | " | 138 | " | " | | | | | |
| 1887 | " | 154 | " | " | | | | | |

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**Obscure Items of Interest.**

WE have on several occasions received letters from some of our readers claiming that certain articles mentioned in the Digest could not be found in the original journals referred to, but in every case without exception we were able to show them that the references were quite correct. We mention this in order to show how easy it is for the reader of a journal to overlook paragraphs of interest which may be hidden among the numerous other matters contained in most journals. If such notes are hard to find when it is known that they are in a certain number of a journal, how much more unlikely would one be to find them if it were not known that they were there. It shows the advantages of having one's attention called to published information, as there are doubtless comparatively few who read over all the journals as carefully as must be done in the preparation of our Digest.

**The Old and the New.**

ON Jan. 6, 1883, THE ELECTRICAL WORLD appeared in an enlarged form, of which the present number is the last issue. Exactly 11 years after, on Jan. 6, 1894, the first issue in a new form, to which we have referred in these columns recently, will appear, and, we trust, will meet with the approval of our readers, in whose interest and for whose convenience the change is made. The 22 volumes issued in these 11 years comprise, it is needless to say, everything electrical that occurred during the most pregnant period of electrical advancement, and to the future historian of the science their large pages will have an interest comparable only to that of the readers who received them fresh from the press. While with the present number THE ELECTRICAL WORLD will leave behind it a record such as few technical papers have had the good fortune to attain, there is no intention to relax any effort. Had there been any thought of resting upon laurels the change from the form familiar the world over would not have been made. The brand-new dress with which we shall begin the year 1894 will be but a token of the keen interest we always feel in the public we serve, and during the coming year our pages will, as usual, give evidence that we say this with the utmost sincerity. We wish our readers a most happy and prosperous New Year.

**Capacity and Self-Induction.**

PROF. CREHORE elsewhere explains in a simple manner the relation of capacity to self-induction in a circuit containing both, and the accompanying curves give the numerical value of the capacity necessary to neutralize any self-induction within the limits given. This subject is coming more into prominence as multiphased currents and long distance electrical transmission of power develop, and the electrical congress paper of Prof. S. P. Thompson on high speed submarine cables opened up still another branch in which it has an important application. As remarked by the writer, it should be borne in mind that the formulas deduced and the curves constructed are all based upon the supposition that the current varies according to the sine law, and that for any other form of current there will be more or less departure. Prof. Pupin has also recently pointed out other considerations which modify the correctness of the assumption that the calculation referred to will enable the self-induction to be exactly neutralized by a capacity if the current even follows the sine law. As it is merely a chance that any current generated by an alternator will follow the sine law, any calculations based upon that assumption are only approximate. There are reasons, however, for having alternate currents approach as nearly as possible to that form, so that it is probable that the discrepancy will not ordinarily be such as to seriously affect values thus deduced.

**Comparison of Systems of Electric Lighting.**

THE comparison of different systems of electric lighting in an article by Mr. Otto Frick, the concluding portion of which is published in this issue, will be found of great interest by electrical engineers on account of the very complete method employed in arriving at the desired result, if not for the general conclusions themselves. All of the conditions are so special, as far as American practice is concerned, that with a similar case and the same method of considering it, an opposite result as to the relative value of the two systems might be obtained. This is evident from the statement of the writer that from the first, of all possible schemes only two had any chance of successful competition—the alternating transformer system and storage battery sub-stations fed from one central station through rotary transformers. As will be seen, the estimates are based upon differential rates for charging for the current, and involved a predetermination as to the average day and season load. While this may possibly be done with some probability of correctness in the case of a conservative European city, much less certainty would attach to such an estimate as applied to one of our rapidly developing cities. Nevertheless, the method employed is a most excellent one, as it removes, as far as possible, doubt as to the validity of the conclusions under the existing conditions. One objection in the eyes of many promoters and of some municipal authorities would be the necessity of a thoroughly competent engineer to undertake such a complete technical study. In the one case the practice of the large electrical companies in relieving possible purchasers of the expense of working out technical details has, notwithstanding the equivocal value of such a system, created an impression that payment for electrical engineering knowledge is something to be evaded; in the other case the exigencies of politics may prevail, and a tyro with a "pull" selected even if the most intricate and technical engineering study is involved.

**Rope Driving.**

IN this issue Prof. Flather continues his important series of articles on rope driving, the first of which appeared in THE ELECTRICAL WORLD of Oct. 21. If they have awakened an interest in this method of transmission of power they will have served a most useful end, although the rapid adoption of direct coupled electrical machinery renders the subject of less importance than it would otherwise have assumed at the present time. As pointed out in the initial article of the series, rope driving possesses a number of advantages, among which are quiet working, applicability to long transmissions, convenience in application, greater freedom from breakdowns and an elasticity which, together with the slackness between pulleys, tend to greater smoothness in running and to neutralize slight periodical variations in speed. On the other hand, greater skill and care have to be exercised in the installation and care of rope drives, while the design of such a system demands a special knowledge not required when leather belts are to be used. For plants in charge of intelligent engineers or under the supervision of professional engineers, rope driving will doubtless be employed more often in the future than in the past, but it is still to be demonstrated by experience if in other cases, particularly with smaller plants, this system possesses a balance of advantages over what may be called the "hardy" leather belt system. The article in this issue incidentally shows the great advantages of direct driving by electric motors, particularly in large engineering shops. A two-inch wrought iron shaft, 625 feet long, for example, is shown to have an efficiency of only 25 per cent., while if 2,500 feet long all the power that could be safely applied to it would be consumed in overcoming its own friction. While in most instances the first cost of an electric transmission outfit for a large workshop will exceed that for shafting, belts, etc., yet the greater efficiency should in all but the most unfavorable cases more than compensate for this, leaving aside the cost of new belting and repairs and attendance to shafting bearings.

**Electric Traction.**

THE next year promises to be an important one in the field of electric traction. The prize offered by the New York Metropolitan Traction Company, to which we referred last week, will attract additional attention to the subject of street railway conduits, which, however, had already assumed considerable proportions, and several new conduit systems now in process of development may soon enter the active field of competition. The Lake Roland elevator electric railway in Baltimore will doubtless serve as a model for similar enterprises, while the completion of the Metropolitan elevated road of Chicago during the next year will place in operation the most extensive system of the kind in the world, even exceeding the similar one at Liverpool, England. The success that has attended the experiment with the Waddell-Entz storage battery system on Second Avenue, New York, is also encouraging in this direction. One of the most favorable points for electric traction lately developed is the unsatisfactory results obtained from the use of the cable in a number of recent instances. It is said that the Broadway cable is far from being satisfactory from a financial point of view, and recently this system was abandoned in a Western city, notwithstanding the large investment in plant, thus almost entirely lost. While a successful electric conduit or storage battery system would thus probably in many instances displace the cable where it is already in use, there is a vast field for them, even should they not be able to compete in economy with cable roads installed under the most favorable conditions, that is to say, on straight routes. In New York, for exampie, one company alone has more than 80 miles of street railway below Central Park with which it would be impossible to use the cable, and many other streets would be available for such roads that are now jealously guarded against the dreaded trolley and the plebeian horse car. The trolley has as yet by no means reached its limitation, but that a limitation to its use exists cannot be denied. While we have no sympathy with the hue and cry against the trolley, we cannot but recognize that, in the larger cities especially, objections against overhead trolley wires in sightly streets have some force. Only overwhelming necessity will permit the adoption of this system in these cases, where but little or no objection would be entertained against a conduit or storage battery system, and either would be eagerly chosen to escape from a threatened infliction of a horsecar road. With the elevated electric road now started on its career, the trolley still unsurpassed for general use, the storage battery system in favorable shape, and the electric conduit system coming to the front, the electric traction industry may be said to be in excellent condition, and the prize above referred to, as well as our announcement last week of the entrance of a new manufacturing firm into the field, shows that this is appreciated by those most directly interested.

## Theory of Hysteresis.

BY CHAS. A. PERKINS.

The energy absorbed by a cubic centimetre of iron when its magnetism is reversed is equal to the area of a curve whose co-ordinates are $H$ and $I$. No doubt many persons are constantly making use of this fact without understanding why it is true. Even in Fleming's work on the "Alternate Current Transformer" (vol. I., p. 65) the reader is referred to a somewhat abstruse paragraph in Maxwell's treatise for the proof.

The following explanation will, however, serve to make the matter plain to any one who understands the definitions of magnetic quantities and the principles of work and energy.

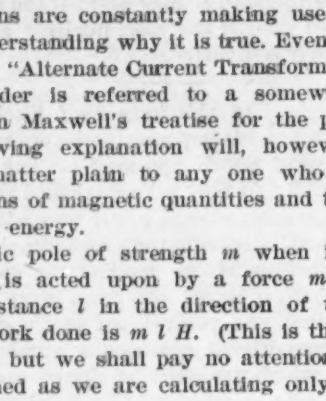
A magnetic pole of strength $m$ when in a field of strength $H$ is acted upon by a force $m\ H$. If it is moved a distance $l$ in the direction of the magnetic force, the work done is $m\ l\ H$. (This is the work done by the pole; but we shall pay no attention to the sign to be attached as we are calculating only the amount of the work.)

Now let us conceive of a magnet whose length can be changed (as if it were made of india-rubber.)

Let one pole stand still and the other be moved by stretching the magnet from a length $l_1$ to a length $l_2$. The work done by the magnetic force will be $H\ m\ (l_2 - l_1)$ or $H\ (m\ l_2 - m\ l_1)$. Now $m\ l$ is the magnetic moment of the magnet, and the intensity of magnetization, $I$, is $\frac{m\ l}{\text{volume}}$.

If for convenience we take a unit volume (one cubic centimetre) then we may write $I_1 = m\ l_1$ and $I_2 = m\ l_2$ and $H\ (I_2 - I_1)$ is the work required to change the intensity of magnetization from $I_1$ to $I_2$. Although we supposed this change to be made by stretching the magnet, it makes no difference how it is done if the final result is the same, and $H\ (I_2 - I_1)$ still represents the work required, whatever be the process of changing the value of $I$.

Now in the diagram let $O\ a$ represent $I_1$ and $O\ b_1\ I_2$, then the area $a\ b\ b'\ a'$ is the value of $H\ (I_2 - I_1)$ and




Theory of Hysteresis.

therefore represents the work required to change the magnetization from $I_1$ to $I_2$. The whole area of the curve is made up of such areas, and therefore represents the energy necessary to perform the process indicated by the curve, viz., to magnetize the iron, demagnetize it, reverse its magnetism and again bring it back to the original condition.

The process of building up such a curve from small slices is familiar to all those who understand the principle of the indicator diagram.

## The American Institute of Electrical Engineers.

At the eighty-second meeting of the American Institute of Electrical Engineers, held at headquarters, New York, on Wednesday, Dec. 20, Mr. Albert Stetson read a paper on "The Practicability of Electric Conduit Railways." After reviewing at greater or less length the various systems of electric street railway traction, Mr. Stetson described in detail the conduit system experimentally operated at Coney Island during the last summer, accounts of which appeared in The Electrical World, of July 1 and Oct. 7, 1893. Various details of the different systems were illustrated by lantern views projected on a screen, and as the entire field of electric conduit traction was gone over, the audience had an unusual opportunity of becoming acquainted with a branch of electrical engineering whose future is steadily becoming brighter. The discussion that ensued was participated in by Mr. Nelson W. Perry, Mr. F. A. Scheffler, Mr. Charles Hewitt and Mr. Joseph Sachs.

The following associate members of the Institute were transferred to full membership:

John L. Hall, Elmer G. Willyoung, Augustine R. Everest, Richard H. Pierce, Harry E. Hayes.

The following gentlemen were elected to associate membership:

H. L. Etheridge, Brooklyn, N. Y.; Chas. T. Linder, Tacoma, Wash.; Frank A. Williams, Newark, N. J.; D. McFarlan Moore, New York City; Arthur Newhall Mansfield, New York City; Charles L. Sturtevant, Washington, D. C.; Prof. Wm. L. Puffer, Boston, Mass.; Louis K. Comstock, Chicago, Ill.; Herbert S. Mustin, Hoboken, N. J.; Harold P. Brown, New York City; Chas. H. Warner, New York City; W. A. McClurg, Plainfield, N. J.; Oliver R. Roberson, New York City; Leonard C. Wason, Brookline, Mass.; Prof. Dr. Johann Sahulka, Vienna, Austria; Prof. W. Le Conte Stevens, Troy, N. Y.; Daniel W. Shea, Champaign, Ill.; C. R. McKay, Salt Lake City, Utah; Mario Capuccio, Corino, Italy; John E. Hudson, Boston, Mass.; Henry Judson Sage, Chicago, Ill.; Francis R. Frost, Ithaca, N. Y.; A. A. Serva, New Industry, O.; A. Marcel Requier, Pittsburgh, Pa.; Charles L. Jaeger, Maywood, N. J.; James W. McCrosky, Baltimore, Md.; Fred. B. Corey, Brooklyn, N. Y.; Elbert F. Norton, Chicago, Ill.

## Economy of Incandescent Lamps.

*To the Editor of The Electrical World:*

Dear Sir: I have just read in your esteemed journal of Dec. 2 your article on the most economical life of incandescent lamps, and in the number of Dec. 16 a short editorial in which a complete resume of the question is given. It is some years since I subscribed for The Electrical World, without which I would not be able to keep abreast of electrical matters in your energetic country, and I am pleased to see that in this matter as in others it is serving in a timely manner the interests of its readers.

The question of the economy of incandescent lamps appears to me to be susceptible of only one solution—that at which you have arrived. In France we have for a long time struggled against the belief that costly long-lived lamps—those of a thousand hours—are the best from the standpoint of economy. The experiments which have been made for months past all tend to prove that short-lived lamps are the most economical, but it is only recently that we have been able to make any impression on those who firmly believed that their lamp of a thousand hours life was the only really economical lamp.

It is not the first time that the question of the economy of lamps has been discussed by you. If I remember rightly you also treated the subject in 1885, and again in 1891 and 1892, when Messrs. Carl Hering and W. D. Weaver renewed attention to it, but I am greatly astonished that the Americans have not yet pushed this question to a practical conclusion; we French are making greater advances on this point. Perhaps it is the cost of the lamp with you that has hindered electrical engineers from getting at the bottom of the matter; but why have they not benefited by the researches that have been made ad nauseam, I may almost say, in France, England and Germany?

Yet the Americans are not stupid, for did they not give us the lamp itself!

The experiments made by our societies and central stations have clearly shown that with the energy at 60 centimes, or 75 centimes (12 and 15 cents) per Kilo-watt it is better to employ a lamp taking 10 watts per hour less than one burning 1,000 hours, because in about 200 hours the cost of a new lamp will have been gained, and one can commence again without loss of light.

Gaston Landais.

## A Photo-Telegraph.

BY H. C. JOHNSON.

I have taken considerable interest in the subject of the transmission of pictures or images by electricity, and in view of the article on this subject which appeared in your issue of Oct. 21, though not claiming to be an electrician, I have concluded to present the results of my own observations. It does not seem

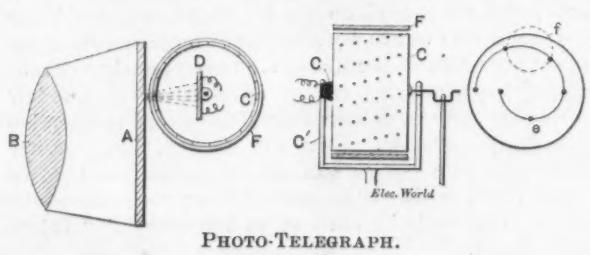



Photo-Telegraph.

improbable that we shall some day be able to produce a device by means of which this much sought for result may be attained. Some one has stated, in substance, that the general principles involved will be the conversion of the picture to be transmitted into a series of electrical pulsations, and afterward causing these pulsations to act upon a receiver at the distant end of the line in such a manner as to reproduce the picture. It seems to me that the next point to be considered is whether it will be possible to transmit each illuminated point in the picture at (practically) the same instant over a single wire, or whether these points are to be transmitted successively, but with such great rapidity that the picture will appear to his eye as complete. I say this is the next point to be considered, for I have given considerable thought to the matter of transmitting each point independently, as, for instance, by separate wires, and while it may be possible even now to devise a construction by means of which the desired result could, theoretically, be realized, it is doubtful if a practical device will ever be made on this principle. The construction described in the article above referred to is based on this idea. Using the words of that writer, "the two instruments would, therefore, be connected by a large cable made up of many thousands of small insulated wires." Imagine, if you can, two telephone instruments connected by one thousand wires, even though they were formed into a cable. The transmission over a single wire of each point in the picture at the same instant would, undoubtedly, be the ideal method, but with our present knowledge it seems, perhaps, somewhat more visionary than the successive transmission of these points with such speed that the picture will appear as a complete thing. When the laws of physics in certain directions are better understood, however, the first method may not prove to be an impossibility. Some little time ago I worked out a device embodying the second method spoken of. While I fully recognize that there are many obstacles which it is difficult to overcome, and it is not claimed for a moment that the present construction does overcome any large proportion of these, yet the instrument has some features which may be of interest.

In the sketches $A$ represents a plate of ground glass on which the picture to be transmitted is first received; in front of this plate is located a lens $B$. The hollow, perforated cylinder $C$, adapted to be revolved by any suitable means, is mounted in a vertically reciprocating frame $C'$ and incloses a selenium cell $D$, which is secured to the frame $C'$ at $C$. The casing $F$, which encircles the perforated cylinder, is provided at that portion nearest the plate $A$ with a narrow horizontal slab, while the perforations or apertures are arranged in oblique lines. As a result, only one perforation at a time can register with the slab in the casing, the object being to allow the rays of light from only one point on the plate $A$ to reach the cell $D$ at any particular instant. It will be seen that the revolution of the cylinder alone will provide for transmitting only one horizontal colored line in the picture, but as the frame carrying the cylinder is simultaneously reciprocated all of the points in the picture will, within a very short space of time, make their individual variation in the resistance of the selenium cell. I regard as especially important the construction whereby each illuminated point is allowed to throw its rays on the selenium cell for only an instant, the light being then entirely cut off until the next perforation registers with the slab. By these means I overcome what seems to be a grave difficulty in certain instruments in which the transmission of points is sought to be accomplished by means of a revolving disc having a series of apertures $e$ arranged spirally near its edge (see Fig. 3), the disc being so located, say, at the end of a tube $f$ through which the rays from the picture pass, that light may reach the selenium cell through only one aperture at a time. The receiver has a similar disc, and both are revolved synchronously. It will be noted that the operation would be what might be termed a "trans mission of lines," that is to say, there would be transmitted through each perforation a curved line of the picture instead of only a point in a line. If the varying shades of an entire line were presented to the selenium cell without intermediate relief by total darkness, the cell would be less efficient, if not utterly useless for the purpose intended. The receiver of the present device consists of a plate similar to $A$, on which the picture is to be reproduced, and a perforated cylinder mounted and revolving in a reciprocating frame. Instead of the selenium cell, however, there is located within the cylinder a source of light and suitable means for varying the intensity of its rays to correspond with the varying strength of the electric current, which in turn depends upon the resistance of the selenium cell, and this resistance varies in proportion to the brightness of the point in the picture which may be influencing the cell at any particular moment. It will be understood that the cylinders must be operated synchronously and with sufficient rapidity to cause it to appear to the eye that all these rays of light of different degrees of intensity are thrown upon the plate at the same instant. It is probable that experiment alone would fully demonstrate how frequently it would be necessary to reproduce each particular point in the picture in order to accomplish this result. Should it be found that the resistance of the selenium cell could not be varied with sufficient rapidity, or that that portion of the receiver designed to throw rays of light of different colors or degrees of brilliancy could not be made to operate properly, the same principle could be extended almost indefinitely by the use of a number of cylinders, with their attachments, each transmitting only a small portion of the picture, although this would, of course, involve a few more connecting wires.

## Electric Light Carbon Making.

The London "Electrician" reports that at a recent meeting of the French Academy of Medicine, M. Lancereaux exhibited the lungs of a polisher of electric light carbon terminals, the said organ being transformed into veritable blocks of carbon. The deceased was, up to the age of 36 years, a vigorous stonemason. He was then transferred to a workshop 26 feet long by 23 broad, where, with eight other men, he was engaged in polishing on stone mills carbons for electric lighting purposes. The shop was so badly ventilated that sometimes the men could not distinguish each other through the charcoal and stone dust filling the atmosphere. Better ventilation and the use of a respirator would have probably rendered M. Lancereaux's pathological exhibit less interesting.

## Electricity in a Modern Hotel.

THE New Netherlands Hotel, one of the most recent additions to the large and constantly increasing number of great hostelries, which have contributed so much to the fame of the metropolis, stands facing the Plaza square at the lower end of Central Park, and in point of situation alone easily surpasses the majority of its rivals. Its proprietors have not, however, been satisfied with so slender a claim to superiority, but have used every means which fancy could suggest and money provide for making the New Netherlands one of the most perfectly appointed hotels in the world. Perhaps the electrical features of the establishment are the best illustration of the completeness with which every plan for the comforts of the guests has been carried out. The interesting features begin in the heart of the installation, the dynamo room, and are in evidence throughout the building.

The maximum number of lights is 6,000, an unusually large capacity for an isolated plant, but only about 3,000 are normally used. The chief point of interest is the use of rope driving, which is not commonly seen in an installation of this character. Power is furnished by two Watts-Campbell Corliss engines, of 350 h. p. and 250 h. p. respectively, and a high speed McIntosh & Seymour engine, of 150 h. p. The Corliss engines are placed at either end of the engine room, and connected by cotton rope drives to a line shaft running along the side of the room close to the wall. A friction clutch coupling in the center makes it possible for either engine to drive separately the whole of the shaft. The flywheels of both engines are 14 feet in diameter, and 1⅜-inch Lambeth cotton ropes lead to 66-inch sheaves on the line shaft, fitted with sleeves and operated by friction-clutches so that the shaft can be thrown in or out of gear while the engine is running.

Four 100 kw. Edison dynamos are driven by rawhide ropes from the line shaft and the high speed engine furnishes power for another Edison machine of 60 kw. The driving sheaves are also fitted with friction-clutches, so that each machine can be thrown in or out as desired. One of the advantages of the rope-driving is the economy of space, and the dynamos in this plant are placed very near the line shaft. In both the dynamo, and engine drives there are two sets of continuous ropes, insuring safety and even distribution of power. The plant was installed by the Link Belt Engineering Co.

The disposition of the lights and the design of the fixtures throughout the building is most artistic. The arc lamps, which ornament as well as illuminate the exterior, are costly and highly wrought structures. Ceiling lights are used with good results, and in the guest rooms very pretty decorative effects are produced by the employment of small 10 c. p. lamps. One of the prettiest fixtures in the house is shown in the accompanying illustration.

A very convenient device in the form of a door switch adds to the convenience of all the closets in the guest rooms. When the door of the closet is opened an incandescent lamp is automatically turned on, and is extinguished as the door is closed. It is so arranged that the door can be left open six inches or so in order to admit air, without the light burning.

Electricity proves useful as well as ornamental in this establishment, and it is applied to almost every operation that requires power. A dozen or more large ventilators on the roof are run by electric motors and are efficient and easily controlled. A small motor operates a buffer in the kitchen, and polishes the silver with a minimum expenditure of time and trouble. One of the elevators affords another illustration of the manifold applications of electricity. In the laundry electricity is also the only source of power, save the muscle of a few laundry girls, which the finer class of work requires. The washing machines and dryers are driven by an Edison motor, and the ironing machine, which runs off linen almost as rapidly as a printing press does paper, is run by the same power. This machine is shown in the accompanying illustration.

The most unique feature of the electrical equipment is the telephone system. This consists practically of a small central telephone station by which every room in the house is connected with the office, and the guests, instead of pushing a button and waiting—perhaps in vain—for a boy, can instantly communicate with the clerk. The advantages of such a system are obvious. The telephone, which is shown in the accompanying illustration, is a small instrument, and the call is made by pressing a button on the side. The switchboard is also shown in the cut. The system has proved most satisfactory in every respect.

## The Braking Question and the Emergency Stop—II.

BY E. A MERRILL.

The use of the motor equipment as an emergency brake is objectionable from every practical standpoint, whether the method be by reversal or by short circuiting on itself. In the first place, its power is entirely inadequate even at the 80 h. p. rate, and this fact alone should condemn its use. Furthermore, it does not fulfill the conditions stipulated above by reversal, it is not "easily controlled," is not "reliable," is not "invariable in its action," is not "incapable of self-destruction"—all for reasons too well known to need repetition. When utilized by short-circuiting it has the further shortcoming of acting only by virtue of motion, a fatal defect on grades.

Even on service stops this method of braking by short-circuiting has few features of merit, and it would further be questionable practice to have two braking systems, one for service and the other for emergency stops and stops on grades, when it is entirely practicable to include both in one mechanism.

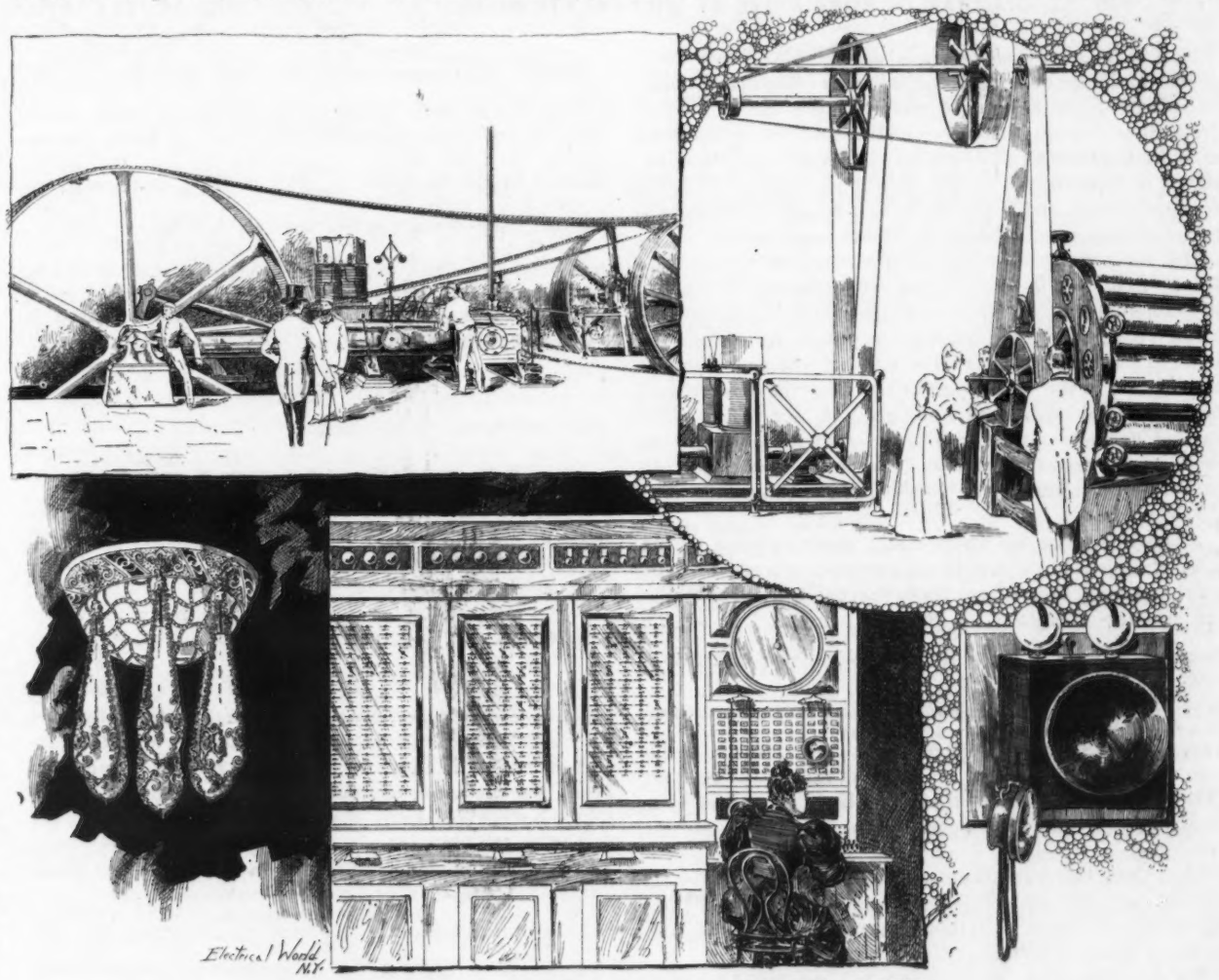
It should be, but apparently is not, self-evident that no braking system can give satisfactory service unless kept in the best condition. The much berated ratchet handbrake is capable, in its province, of doing wonderfully effective work when properly adjusted, and kept adjusted, and in good order; its province is of course somewhat limited, but for single truck cars, at the ordinary speed of eight to fifteen miles per hour, and on roads where emergency stops are comparatively few, it will be difficult to produce a brake more simple, more reliable or more efficient; the fact that on so many roads it has proved inefficient for the sole reason that it has not received proper attention is very weak evidence to prove its inherent weakness or that any other braking system would receive better care or give better results; with double truck cars conditions are present which lessen its availability and increase the relative values of other systems, while at high speeds the coefficient of friction between shoe and wheel is so far reduced that a very considerable pressure is required in order to make the shoe bite; thus throwing on the motorman an amount of physical effort which would soon tire him out.

Accidents cannot be entirely obviated, though the possibility of their occurrence and their frequency can be largely controlled by the adoption of proper precautions. Recognizing the necessity of limitation somewhere in order to keep the number of accidents reasonably small, it has been customary to illogically limit the speed; illogical because speed is, as regards safety, a variable quantity dependent primarily upon the efficiency of the braking mechanism. It requires but a moment's consideration to recognize that any speed is allowable up to the limit of the braking mechanism on an emergency application to bring the car to a full stop within an emergency distance. This distance requires only definition to make it a perfectly constant quantity. The emergency stop distance, therefore, is the proper limitation rather than speed.

A limited maximum speed imposes no obligation upon railway companies to provide either an efficient braking system or a quick and reliable method of motor control; a limited "emergency stop distance" compels both, since only by this means is the highest speed attainable.

The relative small number of accidents chargeable to the electric railway system can neither fairly be placed to its credit nor urged in support of an argument to prove the efficiency of neglected brake mechanism; the number should be much less than it is. A very limited amount of observation will show that in the great majority of instances the apparent necessity for an emergency stop is removed before it becomes an actual necessity; where accidents do occur they are generally traceable to three causes—the necessity arose within the stopping distance, the motorman was careless or lacked judgment, or the braking mechanism, including motor control, was defective—the results of the accident depend upon a combination of causes. Accidents from the first cause are unavoidable; from the second will occur occasionally, but the occasions should be rare; from the third are inexcusable, though that they are an unpleasant reality is amply evidenced by the alarming frequency with which the coroner's jury reports "brakes out of order."

Accidents can be minimized only by the active cooperation of railway companies, their employees, and the public: on the part of the railway companies by providing the most efficient safeguards procurable; on the part of their employees by increased vigilance and the conscientious performance of duties; on the part of the public by exercising a reasonable amount of care and learning to appreciate that a car in motion must, even under the most favorable conditions, travel a certain distance before it can be stopped, that at a given uniform speed it is annihilating space by a definite number of feet per second, and that in crossing tracks in front of approaching cars a factor of safety must be applied ranging in magnitude with the age, activity and sex of the individual.




SOME ELECTRICAL FEATURES OF A MODERN HOTEL.

## Looking Backward.

In a recent after dinner chat an astronomer remarked that it takes 141 years for the light from a certain star to reach us, to which an electrician replied that, as it takes just as long for the light from this planet to reach that star, if the natives, supposing they exist, which they do not, had a sufficiently powerful telescope and directed it toward Philadelphia, they might see Benjamin Franklin out in the fields flying his famous kite, as the image or picture of this historical event has just about reached that star this year. The inhabitants of one of the Pleiades would see Shakespeare with his "only original" company playing in England, and those of the nearest fixed star would see one of the first commercial arc lights used on this planet.

## Carbons for Arc Lamps.

A recent number of the "Electro Techniker" describes an improvement in arc-light carbons, as used by the firm of Krupp, in Essen, which consists in saturating the carbon, or mixing the carbon paste from which they are made, with tungstic acid, or tungstates.

## Rope Driving.—V.

BY. J. J. FLATHER.

An example of rope driving in which the conditions are particularly adapted to this form of transmission was erected two years ago at the works of the Willamette Lumbering and Manufacturing Company, Portland, Ore. The mill is built on piles situated in the Willamette River, while the engine and boiler room are upon the solid ground, some distance away. The engines are a pair of Wheelocks, with cylinders 32 by 60 inches, intended to be speeded to 70 revolutions per minute. The flywheel is 24 feet in diameter by 66 inches face; it is built up of ten segments grooved for thirty-three 1¼-inch manila ropes and fitted to a shaft 20 inches diameter; its weight is 40 tons.

Two ropes are taken from this wheel to jack shafts 35 and 45 feet distant; the driven pulleys—one with 16 and the other with 17 wraps—are each 76 inches in diameter, and are keyed to 10-inch shafts. From the end of each of the jack shafts a 600-h. p. transmission is arranged and carried to the mill. Each shaft is fitted with a friction clutch to allow either of the mill transmissions to be thrown out if desired.

The general arrangement, showing location of driving and driven sheaves, is represented in Figs. 23 and 24, from

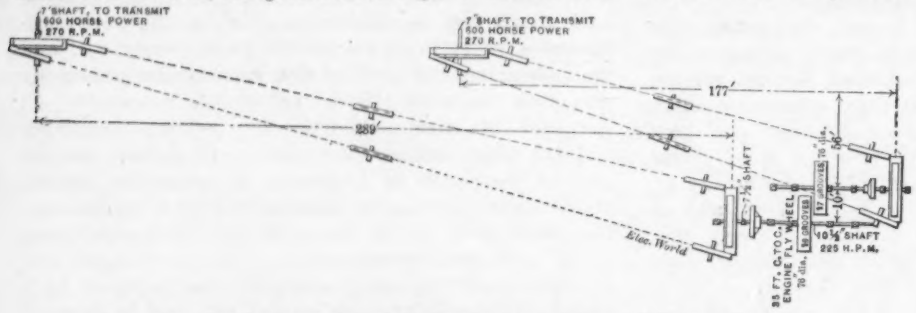

7" SHAFT, TO TRANSMIT 600 HORSE POWER 270 R.P.M.
7" SHAFT, TO TRANSMIT 600 HORSE POWER 270 R.P.M.
177'
289'
7" SHAFT
10½" SHAFT 225 H.P.M.
Elec. World

FIG. 23.—DIAGRAM OF ROPE DRIVE AT WILLAMETTE MILLS.

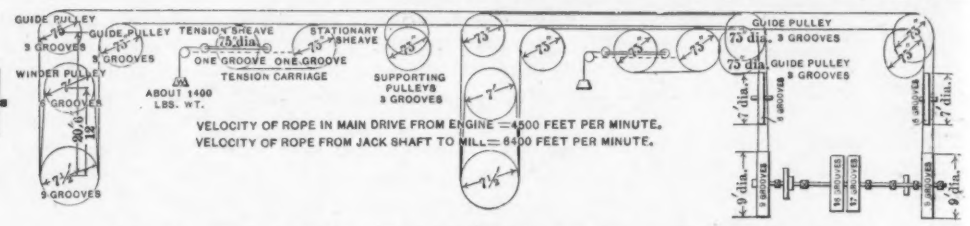



FIG. 24.—ELEVATION OF ROPE DRIVE AT WILLAMETTE MILLS.

which it is seen that power is delivered to two shafts 7 inches in diameter—in the one case at a diagonal distance of about 200 feet, and in the other, at a distance of 185 feet from their respective drivers—both the driven shafts being at right angles with the jack shaft. Each drive was designed to transmit 600 h. p. with a rope velocity of 7,550 feet per minute, but it has since been found advantageous to reduce this speed to about 6,000 feet per minute.

The arrangement of ropes in these transmissions is similar to that used in the Chicago City Railway Company, illustrated above. In the present case only three wraps of 1¼-inch rope are used to convey the power from the jack shaft to the mill, but in order to prevent slip and decrease the tension in the slack part of the rope the driving and driven pulleys have each nine grooves, six turns being carried around another pulley or winder, $B$, thereby increasing the arc of contact and hence the adhesion. In this plant the stress in the rope is greater than that ordinarily used.

It is evident that the whole strain must be borne by the three strands, as it is only the difference in tension of the tight and slack sides of the ropes that can be used to transmit power; therefore the driving force $P = T_1 - T_2$; since $\frac{PV}{33{,}000}$ = h. p., we find the *difference* in tension, $P = \frac{33{,}000 \times 600}{6{,}000} = 3{,}300$ pounds; and as there are three wraps, the difference in the stresses in the two portions of the rope will be 1,100 pounds. As we shall find later, the total stress will be greater than this, due both to the action of centrifugal force in the rope and to the force necessary for adhesion.

The engine has only developed about 700 h. p. as yet, so the total stress in each rope has been very much less than the above; but even with this reduced stress one rope was replaced inside of 15 months.

For short distances, shafting is often employed for such transmissions, but with this latter the friction of the journalbearings is a very important consideration, and effectually debars its use for long-distance transmission.

This will be seen from the following consideration: Let

$\theta$ = distortion of shaft (circular measure) per unit length;

$\theta^\circ$ = distortion in degrees;

$l$ = unit length of shaft;

$L$ = length of shaft in feet = $12\,l$;

$r$ = distance of outer fibres from axis = $\frac{d}{2}$;

$d$ = diameter of shaft;

$PR$ = twisting moment on the shaft;

$N$ = revolutions of shaft per minute;

$v$ = velocity at circumference of shaft = $\pi\, d\, N$;

$G$ = modulus of torsion of the material = $\frac{2}{5}$ of the modulus of elasticity;

$f$ = maximum torsional stress in the outer fibres = $\frac{16\,PR}{\pi\, d^3}$;

$W$ = weight of shaft = 3.36 pounds per foot per square inch of section;

$F$ = load due to friction.

Then
$$\theta = \frac{f\,l}{G\,r} = \frac{32\,P\,R\,l}{\pi\, d^4\, G}. \qquad (1)$$

If the angle of torsion is given in degrees, then $\theta = \frac{\theta^\circ}{360} \times 2\,\pi$; therefore the angular distortion per foot of length will be

$$\theta^\circ = \frac{360}{2\,\pi} \times \frac{f\,L \times 12}{G\,r} = \frac{360\,f}{\pi\,G} \times \frac{12\,L}{d}. \qquad (2)$$

The working limit of the angle of torsion for steel shafting ought not to exceed 0.10 degree per foot in length of the shaft; that is $\theta^\circ = 0.10\,L$, and for wrought iron shafting $\theta^\circ = 0.075\,L$; assuming the shaft to be of steel and substituting the corresponding value for $\theta^\circ$ in (2) we obtain

$$0.10\,L \times \pi\,G\,d = 360\,f \times 12\,L;$$

hence
$$f = 800\,d$$

— if we assume that $G = 11{,}000{,}000$ pounds.

Since the horse power transmitted by the shaft equals $PR \times \frac{2\,\pi\,N}{33000}$, if we substitute the value of $PR_1 \left(= \frac{\pi\,d^3}{16} f\right)$ there is obtained: h. p. $= \frac{\pi\,d^3}{16} f \frac{2\,\pi\,N}{33000}$; but the velocity at the circumference of the shaft is $v = \pi\,d\,N$, also $f = 800\,d$; hence

$$\text{h. p.} = 0.0095\,d^3\,v. \qquad (3)$$

If the bearing is well worn and fitted to its shaft the resistance due to friction will probably lie between the limits $\frac{\pi}{2}\,\varphi\,W$ and $\frac{4}{\pi}\,\varphi\,W$, or between $1.57\,\varphi\,W$ and $1.28\,\varphi\,W$, where $\varphi$ is a coefficient, which in the present case we shall assume equal to 0.06.

Taking the lesser value we shall have $F = \frac{4}{\pi}\,\varphi\,W$, where $F$ is the force at the circumference of shaft necessary to overcome the journal friction. If there are no pulleys on the shaft $W = \frac{\pi}{4}\,d^2\,L \times 3.36$; the horse power exerted to overcome the friction will then be

$$\text{h. p.}_0 = \frac{F\,v}{33000} = \frac{4}{\pi}\,\varphi \times \frac{\pi}{4}\,\frac{d^2\,L \times 3.36\,v}{33000} = .0^5\ 6\ d^2\,L\,v.$$

Expressed as a ratio the percentage of power required to overcome friction will be

$$\frac{\text{h. p.}_0}{\text{h. p.}} = \frac{0.0^5\ 6\,d^2\,L\,v}{0.0095\,d^3\,v},$$

from which there is obtained

$$\text{h p.}_0 = 0.00063\,\frac{L}{d}\,;\ \text{h. p.}_0 = \frac{L}{d} \times \frac{\text{h. p.}}{1585}.$$

That is, for a steel shaft whose diameter is one inch, the horse power required to overcome the friction in a length of 1,585 feet will be equal to the total allowable transmitting capacity of the shaft.

For wrought iron $\theta^\circ = .075\,L$ and h. p. $= .0075\,d^3\,v$ from which may be determined the value of the ratio

$$\frac{\text{h. p.}_0}{\text{h. p.}} = 0.0008\,\frac{L}{d}, \text{ or h. p.}_0 = \frac{L}{d} \times \frac{\text{h. p.}}{1250}.$$

The following tables, calculated from these formulas, give the limits at which the power transmitted by a shaft is absorbed by the friction of the bearings, the assumption being that the factor of journal friction $\varphi$ equals 0.06, and that the allowable twist shall not exceed 0.10 degree per foot of length for steel, nor .075 degree for wrought iron. The shaft is supposed to be free from all pulleys and gears.

TABLE I.—LIMIT OF LENGTH FOR STEEL SHAFTING.
No pulleys on the line.

| Diameter of shaft in inches. | Length in feet when total power is absorbed. | Length when efficiency = 50 per cent. | Length when efficiency = 25 per cent. |
|---|---|---|---|
| 1 | 1,585 | 792 | 396 |
| 2 | 3,170 | 1,585 | 792 |
| 3 | 4,755 | 2,377 | 1,188 |
| 4 | 6,340 | 3,170 | 1,585 |
| 5 | 7,925 | 3,962 | 1,981 |

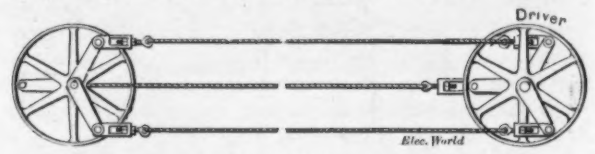
TABLE II.—LIMIT OF LENGTH FOR WROUGHT IRON SHAFTING.
No pulleys on the line.

| Diameter of shaft in inches. | Length in feet when total power is absorbed. | Length when efficiency = 50 per cent. | Length when efficiency = 25 per cent. |
|---|---|---|---|
| 1 | 1,250 | 625 | 312 |
| 2 | 2,500 | 1,250 | 625 |
| 3 | 3,750 | 1,875 | 937 |
| 4 | 5,000 | 2,500 | 1,250 |
| 5 | 6,250 | 3,125 | 1,562 |

From the foregoing it will be seen that shafting is altogether unsuitable for conveying power any considerable distance, and as belting is not adapted to this work choice must be made of some other method.

For a mere dead pull, such as the alternate strokes needed to operate a pump, work is, and has long been transmitted to very great distances; as by the long lines of draw rods, ropes or wires used in mining regions, quarries and elsewhere, for transmitting the power of a water wheel by means of a crank on its main axis, pulling during half its revolution, against a heavy weight at the end of the line and thus storing up energy for the return stroke

Rods and wire ropes have also been used to transmit rotary motion to a considerable distance in a similar manner by placing the cranks at 120 degrees, as shown in Fig. 25.




ROPE DRIVES WITH CRANKS AT 120 DEGREES.

It is evident that the distance of transmission by this contrivance will be subject to the sag of the ropes, unless intermediate shafts are employed. The motion must also be comparatively slow, owing to the severe strains which would be thrown upon the bearings and pins by the surging and swaying of the ropes during the rapid changes of motion to which they would be liable. In order, then, to transmit much power, heavy rods or large ropes would be necessary, and under these conditions economical transmission would be limited to short distances.

Among the various means in use at the present time for conveying power to a distance we find steam, water, gas, compressed air, electricity and rope systems. Each of these has its own applications and advantages, but it must be borne in mind that with the exception of rope transmission, of which numerous examples have already been given, all other forms require a generator at the one end and a motor, and usually separate attendants, at the other.

Other things being equal, the relative merit of various methods of transmitting power will be indicated by the cost of transmitting a certain amount of power to any given point, as compared with the cost of this power at the generating station, while their absolute merit will be shown by comparing the cost of the transmitted power at the receiving station with the cost of producing the required power directly at this point.* Such determinations are materially affected by variations in the amounts of power and in the distance of transmission, the other principal factors to be considered being the efficiency of the system, the number of working hours per annum, the price of 1 h. p. per hour at the generating and receiving stations, and the convenience and applicability of the system to each special case.

The efficiency of any system of transmitting power is expressed by the ratio of the power obtained at the receiving station to the power given out at the generating station. In all systems, losses of power of greater or less magnitude occur, and the most efficient system is that in which those losses are reduced to a minimum. We shall not attempt here to lay down rules governing the choice of any particular method, for the requirements and conditions are so varied that every individual case must be decided upon by the engineer separately with a knowledge of all the facts before him. Our present object is to ascertain the principles governing the use of ropes, and to determine those conditions best suited to their economic working.

*(To be continued.)*

## Laboratory Notes.—XIII.

BY LIEUT. F. JARVIS PATTEN.

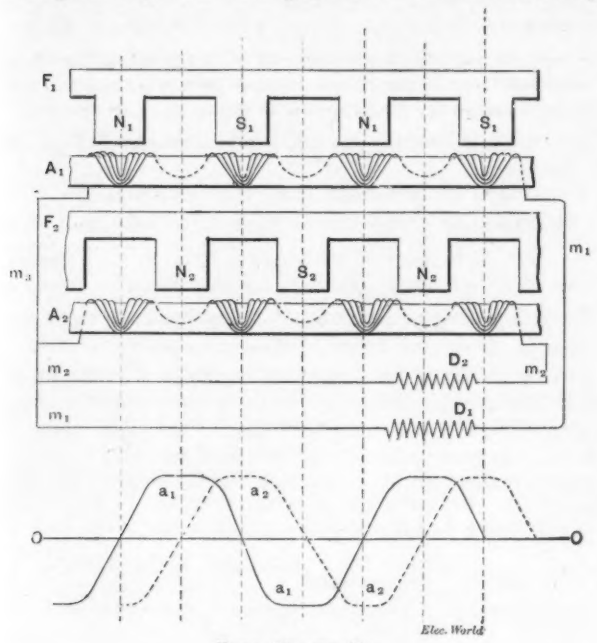
Before leaving the discussion of the pulso-alternating current to which the last paper was devoted it seems worth while to consider briefly the other ways, if any there may be, of generating this sort of current. The methods I first used for obtaining it and for operating such a motor system as that shown in Fig. 27, which was originally built for a rotary field machine to be operated by quadrature currents, are interesting, inasmuch as they show how an experiment undertaken for one purpose will sometimes lead to the elucidation of some entirely unexpected and novel idea.

As before remarked, it is not every alternator that can be made to give such a current without some sort of commutator or process of rectification, which may be generally considered objectionable; with such a rectifying process, however, any single alternating current can be put into the form shown in Fig. 30b by simply reversing every other pair of impulses (the shaded ones) of the single alternating current indicated in Fig. 30a. Such a plan is, however, objectionable; for even when this much has been done the component currents are not yet separated, and that of course will require still another commutating process of some kind, whereas the divided alternator with a ring armature like that shown in Fig. 26 produces the required current by yielding its two components without rectifying process of any kind to two independent circuits and the recombining is simple.

* "Use of Belting," Cooper, p. 285.
* Stahl.

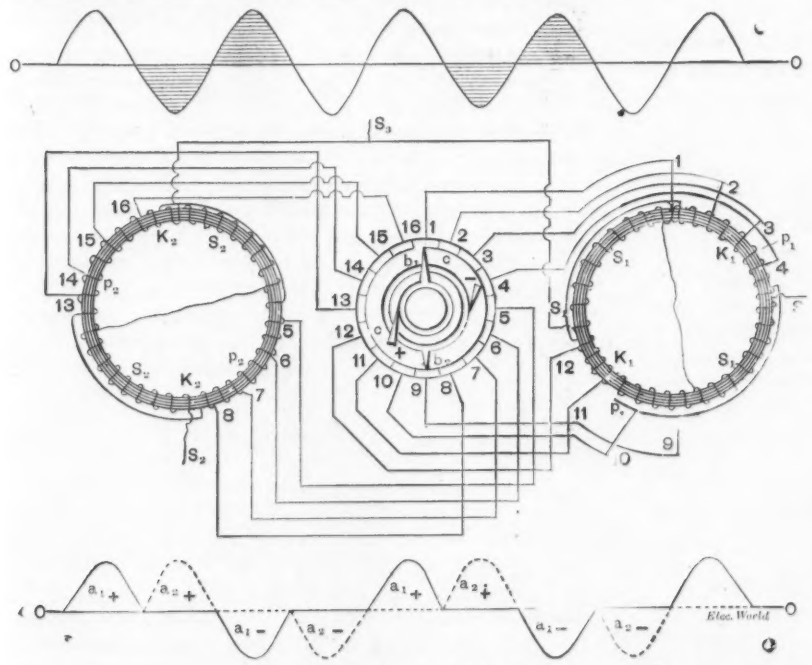
If, however, any other form of alternator than that having a Gramme ring armature be taken, an entirely different current will result. Thus the form indicated in the diagram, Fig. 29, which may be compared to the Westinghouse and Thomson-Houston types having the coils laid flat upon the cylindrical surface of the armature, comes under the general type of Lontin machine or polar armature type.

An examination of the induction change that takes place in this machine shows that the current is at a zero value when the centre of the armature coil is opposite the centre of the poles, and such a current cannot be given a prolonged zero value, though its maximum duration may be slightly prolonged. We shall then have from this type of machine when built in the double form shown in Fig. 29 two currents in quadrature as shown in Fig. 29a. The plan first used for obtaining




FIGS. 29 AND 29A.

the pulso-alternating current is shown in Fig. 30, where $K_1$ $K_1$ and $K_2$ $K_2$ are two independent ring converters, having each their primaries $p_1$ $p_1$ wound in opposite quadrants, and their secondaries, $S_1$ and $S_2$, wound in the intermediate quadrants. Now, I started to take from these converters two currents in quadrature which I was after at first, and which it will be seen can be taken from the two secondaries if the two primaries are connected in series as a single continuous ring winding, except that one-half the winding is in two opposite quadrants of one ring, and the other is in the intermediate quadrants of the other ring as shown in




FIGS. 30A AND 30B.

Fig. 30. The 16 different points of the entire winding were then connected up Gramme ring fashion to a fixed commutator $C$ $C$, having 16 segments over which travel two revolving brushes, $b_1$ $b_2$, through which a direct current is introduced to the primary windings, moving of course the polar line of the two rings as the brushes sweep around the circle. Such an arrangement will give perfect quadrature currents in two circuits attached both to the terminal $S_3$ and one each to $S_1$ and $S_2$. There need be little or no sparking, as the ring is continuous, and the same iron is continuously magnetized to the degree of saturation.

Let us inquire now what will happen if, instead of connecting the two primaries up as a single continuous ring winding, each primary on its own ring is treated as a separate independent circuit, the commutator serving only to send the direct current first one way and then the other through the two independent primaries in succession. The diagram, Fig. 30, shows the two converters with their primaries connected on this plan.

As the brushes on the commutator sweep over the segments 1, 2, 3, 4 and 9, 10, 11, 12, current is sent one way to the primary of the converter $K_1$; then as they pass over the segments 5, 6, 7, 8 and 13, 14, 15, 16, current is being sent the same way through the primary of converter $K_2$ and *none at all* which is important will in the meantime be going through the primary of $K_1$, and there will be no induced current in its secondary coil. We shall therefore have a period of zero current in the secondary of the converter $K_1$ that corresponds in time exactly to the period of activity of the secondary $S_2$ of the other converter. Following the brushes through another quadrant we find that the primary of converter $K_1$ now gets the current again, but in a reverse direction to that in which it was sent to it before; then the secondary of this converter for the time yields a negative impulse. The primary of the converter $K_2$ then gets the current for a quadrant period in the reverse direction, and its secondary then gives an impulse of negative current. From the two converters arranged in this manner we obtain therefore two currents like those indicated full and dotted in Fig. 30b, first two positive, and then two negative, impulses, or a pulso-alternating current as shown. It is interesting to note how entirely different an effect is obtained depending simply upon the condition whether the two primaries on the different rings are connected up together in series Gramme ring fashion as a continuous winding or are connected to the collector as independent circuits comparable to the two cases of a closed and open coil dynamo; the first method gives in the secondaries two independent currents in quadrature, whereas the other gives the components of the peculiar pulso-alternating current of Fig. 30b.

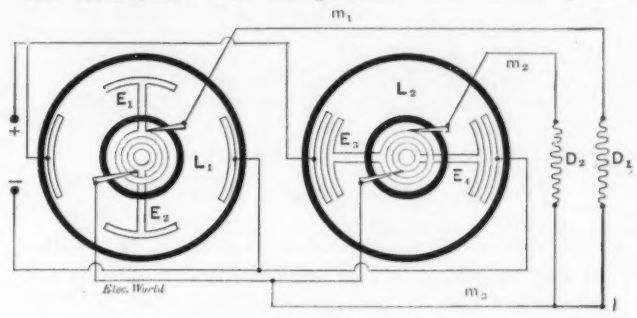



FIG. 31.

Another plan was then tried with similar results. This is shown in Fig. 31, which shows two liquid commutators $L_1$ $L_2$ similar to that described in a previous paper of the series. The terminals + and — of a source of direct current are taken to the fixed electrodes of the two tubs, and the spindles of the revolving electrodes are so geared as not only to revolve synchronously, but to maintain the positions indicated at right angles to each other, if the fixed electrodes are in the same right line.

Under these conditions the two commutators would ordinarily give two currents in quadrature—but not necesosarily so, for it will be seen that if the fixed and revolving electrodes are both made very small or, more exactly, are only allowed to extend over a comparatively small arc of the entire circumference, then there must be a prolonged period of zero current and a comparatively short period of activity, so that where one of the commutators, as $L_2$, is at a period of maximum current the other is not only giving no current to its circuit, but will continue not to give any for a considerable distance, which can, of course, be made to correspond to an eighth part of an entire revolution, in which case these two liquid commutators will yield two single currents, which combined produce a true pulso-alternating current. Another very interesting application of the contrivance shown in Fig. 30 will be briefly referred to here, though it belongs properly to the question of the rectification of alternating currents, which will receive treatment later.

We have seen how a direct current introduced at the brushes + and — bearing on the collector, Fig. 30, send a direct current first one way through the primary $p_1$ of the converter $K_1$ on the right, then the same way through the primary $p_2$ of the converter $K_2$ on the left. Then simply because the current entering at the brushes + and — is direct current and is thus reversed with respect to the primaries as the brushes revolve around, the resulting current in the secondaries is an alternating current. Let us now inquire what will happen if first an alternating current is introduced at the brushes + and — and second that these brushes be caused to revolve synchronously so that a + current will correspond to a passage of the brushes over the segments 1, 2, 3, 4, a negative impulse of the current to their passage over the segments 5, 6, 7, 8, then a positive impulse to the next quadrant and a negative to the next, and so on.

We have only to remember that a negative current sent through a circuit in a direction which we will call backward produces the same magnetic effect as a positive current sent the opposite way or forward, and we will see that all the impulses from the two secondaries $S_1$ and $S_2$ as they occur in rotation will be of the same sign or direction, and when superposed as before we shall have a pulsating direct current like that shown in Fig. 19 as a result of introducing an alternating current to this system under the conditions named, that of synchronous rotation, and the spacing of the impulses so that each shall correspond to a quadrant belonging to one of the primaries. We therefore have here a novel system of obtaining a sort of direct current, at all events a current all the impulses of which are of the same direction or sign, from a single alternating current, and this without immediate commutation of the latter—the resulting direct current being, so to speak, an induced secondary. Now as it may be well objected that such a pulsating direct current is at best a poor makeshift as compared with a uniform direct current—a double system of the above description supplied with two alternating currents in quadrature will give a fairly uniform direct current, but probably not so smooth as that derived from quadrature currents by means of our motor dynamo methods previously described.

## A $50,000 Street Railway Prize.

The offer of a prize by the New York Metropolitan Traction Company for a street railway system superior to the trolley or cable, to which we referred editorially in our last issue, is contained in a letter to the New York Board of Railroad Commissioners, which we print below. While the commissioners were unable to accept the conditions of the letter as proposed, they have offered to co-operate with the Metropolitan company as far as may lay within their power. It is understood that a section of track on 50th street will be used for experimenting on the inventions offered, and that one of the members of the traction company is now experimenting elsewhere on a conduit system. The letter is as follows:

On streets where the lines are straight and the business is heavy, the cable system is the most economical yet invented. For general use in a city, winding about through the streets and following the routes of travel which the public wish to pursue, it is impracticable. You require straight routes for cable roads. We have in addition to the lines upon which the cable will be laid, over 80 miles of street railroads now operated with horses, all below the Central Park. It is to these lines in particular that we now desire to direct your attention.

Up to the present time the only system whose practicability has been demonstrated is the overhead trolley. We are well aware, however, that its application in the streets of New York would not meet with the approval of the community. What we most desire now is to hasten the development and perfection of a better system. We therefore submit the following proposition:

First—We will set aside the sum of $50,000, to be awarded as a prize to any person who shall, before March 1, 1894, submit to your honorable board an actual working system of motive power for street railway cars demonstrated to be superior or equal to the overhead trolley.

Second—The qualities necessary to meet this requirement shall be left to your decision; but with the present state of the art, a system to win the award must necessarily approximate the trolley as a standard of economy in operation, but should be without the features in it objectionable to the public.

Third—We shall exact no rights in the invention in return for the $50,000, and shall have nothing whatever to do with the making of the award further than to pay any expenses which your honorable board may deem necessary or wise to incur, either in the employment of experts, the giving of hearings, or the conduct of experiments—this in order that no effort may be spared to achieve the desired result.

## Electricity at the World's Fair Grounds.

The work of the removal of exhibits from the World's Fair buildings has been considerably delayed during the past few days on account of the cold weather, and much difficulty seems to be experienced in obtaining cars, and having same located. The foreign exhibitors, moreover, are experiencing many delays with the custom house officials, and but a very small proportion of the foreign exhibits has been shipped. Most of them, however, are dismantled and packed. The excessive care which the foreigners exercise in packing their shipments is a subject of constant remark. The great Schichau vertical engine in Machinery Building, with its Siemens & Halske dynamo, is entirely dismantled and ready for shipment.

The domestic exhibits are nearly all gone, only some of the largest machines of those in the Electricity Building, and the electric plant in Machinery Building, are still remaining. The General Electric Company has shipped "all that is mortal" of one of the memorable twin electric fountains to the Midwinter Exposition, to San Francisco, and one of their large generators has also gone there to supply the light for the fountain, and eight of the T.-H. arc dynamos with 400 lamps have gone to the same place, as well as six of the ten Western Electric arc machines. Most of the remaining 20 T.-H. machines were sent in single shipments to various stations about this territory, though a few were returned to Lynn.

Most of the Fort Wayne arc dynamos are still in the building, though two have gone to the Midwinter Fair. All of the Brush machines are out. Ten of these were sent to the Boston Electric Light Company, and two to Rock Island, and the four others, separately to various stations.

The wiring for the arc lights, except the patrol circuits, is now nearly all out of the ground except that which is in the subway, none of the wires there having as yet been removed, except only a very few of the power lines. The wire which is being removed from the ducts is found to be in an unexpectedly good condition, and is practically as good as new. This wire reverts to the New York Insulated Wire and Cable Company, by which it was furnished.

Most of the wiring for the local telephones has been removed, including all that in the north end of the Park, and all of the secret service "detective phones" are removed. The police and fire alarm boxes are still in place, although the contract for the use of these expires on Jan. 1. The Chicago Telephone Company's switchboard, which attracted so much attention during the Fair, is still in its place, though many of the phones are cut out, and soon the station will be put out of service, those remaining in the Park being connected into the Oakland Exchange.

## Theory of the Transformer.*—X.†

BY FREDERICK BEDELL AND ALBERT C. CREHORE.

In the previous article the effects were shown which are produced by a variation in the coefficients of induction of a transformer with no magnetic leakage or external secondary self-induction. We will now proceed from the simpler to the more general case.

### EFFECTS PRODUCED BY A VARIATION OF THE MUTUAL INDUCTION CAUSED BY CHANGING THE RELUCTANCE OF THE MAGNETIC CIRCUIT IN A TRANSFORMER WITH EXTERNAL SECONDARY SELF-INDUCTION.

*Constant Primary Current.*—We will first consider the case in which the primary current is maintained constant.

External to the transformer is a constant self-induction $L_\varepsilon$ in the secondary circuit. The coefficient of mutual induction $M$, and the self-inductions of the transformer, primary and secondary, $L_1$ and $L_t$ respectively, vary inversely with the reluctance of the magnetic circuit, while all other quantities remain constant. The secondary self-induction, being the sum of the "internal," or that in the secondary coil itself, and the external, is

$$L_2 = L_t + L_\varepsilon$$

We also have the relation $M^2 = L_1 L_t$ for the case of no leakage.

### SECONDARY ELECTROMOTIVE FORCE.

In Fig. 32, $\overline{OA}$ represents the constant primary electromotive force; $\overline{OB}$ is the induced secondary electromotive for a particular value of $M$, and $\overline{OC}$ the corresponding secondary electromotive force which overcomes ohmic resistance. As $M$ varies, the position of the point $C$ will change.

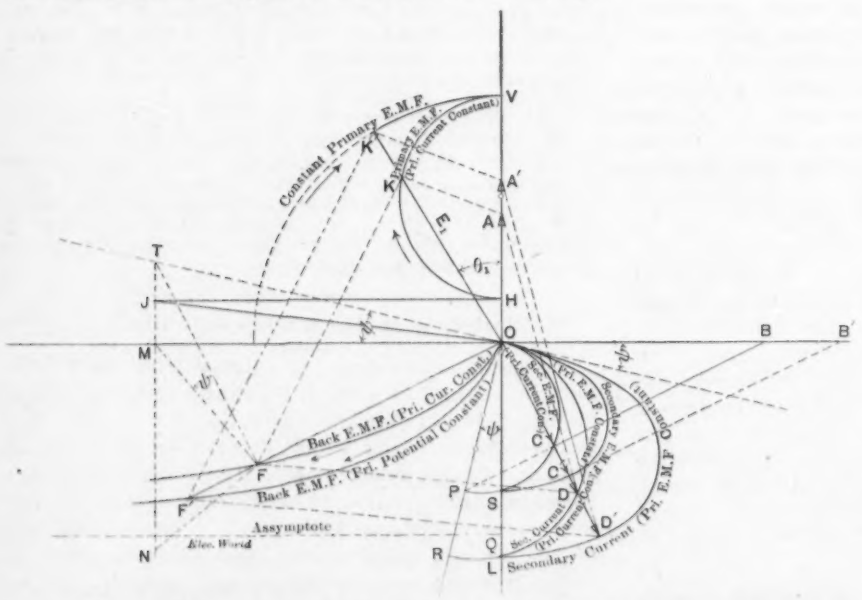



FIG. 34.—CONSTANT POTENTIAL TRANSFORMER WITH EXTERNAL SECONDARY SELF-INDUCTION. TYPICAL DIAGRAM FOR A VARIATION IN THE MUTUAL INDUCTION.

It is now required to find the locus upon which it will always lie.

From the triangle $OBC$, we have

$$\overline{OC} = M\,\omega\,I_1 \cos\theta_2\,;$$

and $$\tan\theta_2 = \frac{L_2\,\omega}{R_2} = \frac{L_t\,\omega}{R_2} + \frac{L_\varepsilon\,\omega}{R_2} = \frac{M^2\,\omega}{L_1 R_2} + \frac{L_\varepsilon\,\omega}{R_2}.$$

Hence, $$M\,\omega = \frac{L_1}{M} R_2 \tan\theta_2 - \frac{L_1}{M} L_\varepsilon\,\omega$$

and $$\overline{OC} = \frac{L_1 I_1 R_2}{M}\sin\theta_2 - \frac{L_1 I_1 L_\varepsilon\,\omega}{M}\cos\theta_2, \quad (125)$$

or, $$\overline{OC} = \frac{L_1 I_1}{M}(R_2 \sin\theta_2 - L_\varepsilon\,\omega\cos\theta_2).$$

Transforming into terms of the sine alone, we have

$$\overline{OC} = \frac{L_1 I_1}{M}\sqrt{R_2^2 + L_\varepsilon^2\,\omega^2}\,\sin(\theta_2 - \psi), \quad (126)$$

where $$\tan\psi = \frac{L_\varepsilon\,\omega}{R_2} = \text{a constant.}$$

In this equation, (126), $\theta_2$ is the only variable. The locus of $C$ is therefore a circle upon a diameter

$$\frac{L_1 I_1}{M}\sqrt{R_2^2 + L_\varepsilon^2\,\omega^2}.$$

To locate this diameter in Fig. 32, make the angle $SOP$ equal to $\psi$ and produce $\overline{BC}$ to $P$. The angle $OPC$ is equal

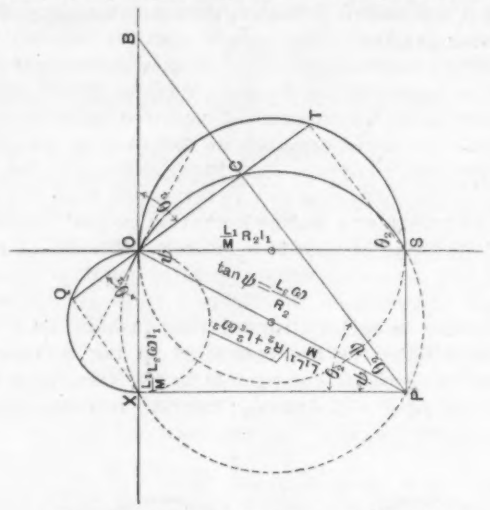



FIG. 33.—DETAIL PORTION OF FIG. 32.

to $(\theta_2 - \psi)$. Hence $\overline{OC} = \overline{OP}\sin(\theta_2 - \psi)$. Evidently the locus of $C$ is a semicircle with a diameter

$$OP = \frac{L_1 I_1}{M}\sqrt{R_2^2 + L\varepsilon^2\,\omega^2}.$$

This is geometrically shown from equation (125) in Fig. 33. Lay off $\overline{OS}$ and $\overline{OX}$ at right angles to each other and equal, respectively, to the coefficients of the sine and cosine in equation (125). Erect the semicircles $OQX$ and $OTS$. We have from the figure:

$$\overline{OT} = \frac{L_1 I_1 R_2}{M}\sin\theta_2;\ \overline{OQ} = \frac{L_1 L_\varepsilon\,\omega\,I_1}{M}\cos\theta_2.$$

Hence from equation (125)

$$\overline{OC} = \overline{OT} - \overline{OQ}.$$

The locus of $C$ is accordingly a semicircle whose diameter $\overline{OP}$ is the diagonal of the rectangle on the component diameters $\overline{OS}$ and $\overline{OX}$. When there is no external self-induction, $\overline{OX}$ disappears. $\overline{OX}$ increases with $L_\varepsilon$ and has the ratio $\frac{L_\varepsilon\,\omega}{R_2}$ to $\overline{OS}$.

### SECONDARY CURRENT.

The secondary current $\overline{OD}$ is equal to $\overline{OC}$, which is equal to $R_2 I_2$), divided by $R_2$ and must, therefore, have a similar locus. Referring to the expressions for $\overline{OC}$, in (125) and (126), we have

$$I_2 = \overline{OD} = \frac{L_1 I_1}{M}\left(\sin\theta_2 - \frac{L_\varepsilon}{R_2}\frac{\omega}{}\cos\theta_2\right) = \frac{L_1 I_1}{M}(\sin\theta_2 - \tan\psi\cos\theta_2) = \frac{L_1 I_1}{M\cos\psi}\sin(\theta_2 - \psi) = \overline{OR}\sin(\theta_2 - \psi). \quad (127)$$

The locus of $D$ is a semicircle $ODLR$ with a diameter

$$\overline{OR} = \frac{L_1 I_1}{M R_2}\sqrt{R_2^2 + L_\varepsilon^2\,\omega^2}. \quad (128)$$

It is to be noticed that the lines $\overline{OS}$ and $\overline{OL}$ in Figs. 32 and 33 have the same values as in Figs. 26 and 27 of the last article.

### BACK ELECTROMOTIVE FORCE.

The back electromotive force $E_b$ is always equal to $M\omega\,I_2$, and is 90 degrees behind the secondary current. Referring to equation (127) we have

$$E_b = \overline{OF} = M\,\omega\,I_2 = \frac{L_1\,\omega\,I_1}{\cos\psi}\sin(\theta_2 - \psi). \quad (129)$$

If a line $\overline{OT}$ be drawn making an angle $\psi$ with $\overline{OM}$, and if $\overline{JT}$ be drawn from $J$ perpendicular to $\overline{HJ}$, we have $\overline{OT} = \frac{L_1\,\omega\,I_1}{\cos\psi}$. The line $\overline{OT}$ is a variable depending upon the value of $L_1$. Substituting in (129):

$$E_b = \overline{OF} - \overline{OT}\sin(\theta_2 - \psi).$$

Hence the point $F$ is upon a semicircle with $\overline{O\ T}$ for a diameter, and $\overline{FT}$ is perpendicular to $\overline{OF}$.

The locus for the back electromotive force may be constructed by points located graphically in accordance with the above relations. The line $\overline{OF}$ is drawn at right angles to $\overline{OD}$, the secondary current for any particular values of the coefficients of induction. On the line $\overline{OT}$ the point $T$ is located, corresponding to these same values of the coefficients of induction. From $T$ a line $\overline{TF}$ is drawn perpendicular to $\overline{OF}$. The intersection $F$ is a point on the back electromotive force locus. Other points are obtained in the same way, and the whole curve thus determined. The curve is tangent to $\overline{OP}$, and approaches $\overline{QX}$ as an asymptote.

### PRIMARY IMPRESSED ELECTROMOTIVE FORCE.

The primary electromotive force is the vector sum of $\overline{FO}$, $\overline{OH}$ and $\overline{HJ}$, and is therefore equal to $\overline{FJ}$. Drawn from $O$ as an origin the primary electromotive force is $E_1 = \overline{OK} = \overline{FJ}$. The locus of $K$ is a semicircle upon the diameter $\overline{H\ V}$, as will now be shown.

In the triangle $MFT$, the angle $MFT$ is equal to $\psi$, since the points $M$ and $F$ lie upon a semicircle described upon $\overline{OT}$ as a diameter, and since the angle $MFT = MOT = \psi$, each subtending the same arc $MT$. In the triangle $MFT$ we accordingly have $MF : MT :: \cos\theta_2 : \sin\psi$.

But $MT = L_1\,\omega I_1 \tan\psi$. Hence

$$MF = \frac{L_1\,\omega I_1}{\cos\psi}\cos\theta_2 = \frac{L_1}{M}\cdot\frac{M\,\omega\,I_1}{\cos\psi} = \frac{L_1\ \overline{OC}}{M\cos\psi}.$$

But $\overline{OC} = \overline{OP}\sin(\theta_2 - \psi)$. Hence

$$\overline{MF} = \frac{L_1\ \overline{OP}}{M\cos\psi}\sin(\theta_2 - \psi). \quad (130)$$

If $\overline{FN}$ is drawn perpendicular to $\overline{FM}$, we have in the triangle $FMN$

$$\overline{MF} = \overline{MN}\sin(\theta_2 - \psi) \quad (131)$$

It follows directly from (130) and (131) that

$$\overline{MN} = \frac{L_1\ \overline{OP}}{M\ \cos\psi}. \quad (132)$$

Since $\overline{OP} = \frac{L_1 I_1}{M}\sqrt{R_2^2 + I\varepsilon^2\omega^2}$ (see Fig. 33) and $\cos\psi = \frac{R^2}{\sqrt{R_2^2 + L_\varepsilon^2\,\omega^2}}$, we have

$$\overline{MN} = \frac{L_1^2\ I_1}{M^2\ R_2}\left(R_2^2 + L\varepsilon^2\,\omega^2\right) = \text{a constant.} \quad (133)$$

Since $MFN$ is a right angle, the point $F$ always lies upon a semicircle with a diameter $M\bar{N}$ constant in value, but shifting in position as $\overline{HJ}$ increases. The back electromotive force locus might have been constructed in this way:

To locate the locus of the primary electromotive force, draw $\overline{HV}$ equal and parallel to $\overline{MN}$. Then $HK$ will be equal and parallel to $\overline{FM}$ and $\overline{OK}$ equal and parellel to $\overline{FJ}$. Evidently the locus of $K$ is the semicircle $HKV$ with a diameter $\overline{HV} = \overline{MN}$ as given in (133).

As the external secondary self-induction is made smaller, the angle $\psi$ is diminished. When there is no external self-induction, $\psi = L_\varepsilon = 0$. The value of $\overline{HV}$ then takes the simpler form given in Fig. 26 of the previous article.

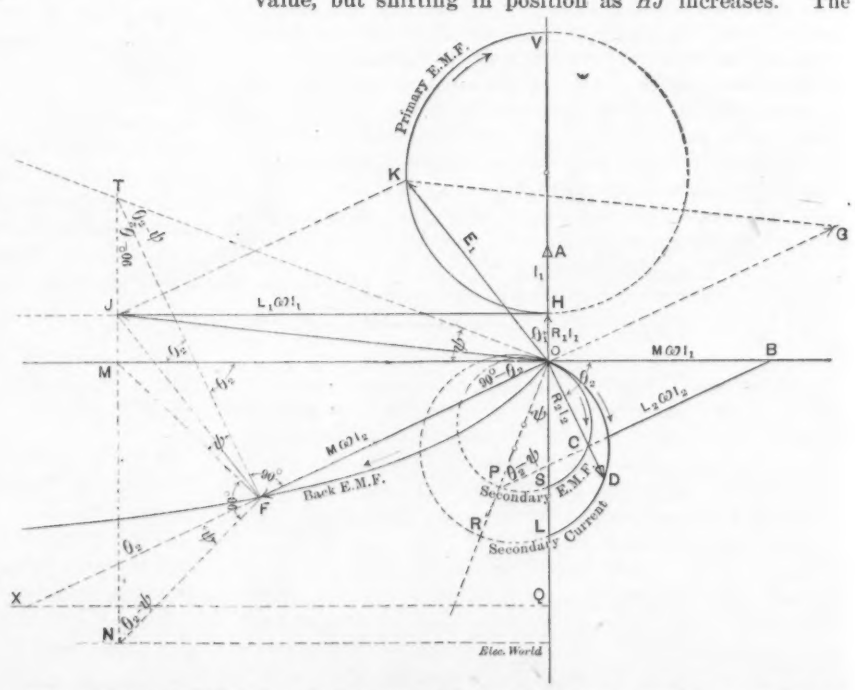



FIG. 32.—CONSTANT CURRENT TRANSFORMER WITH EXTERNAL SECONDARY SELF-INDUCTION. TYPICAL DIAGRAM FOR A VARIATION IN THE MUTUAL INDUCTION.

* All rights reserved.

†For the previous section of this article see THE ELECTRICAL WORLD of Dec. 23, 1893.

*Constant Primary Potential.*—The figure showing the effects produced by varying the coefficients of induction in a constant potential transformer is given in Fig. 34. The construction is first made for a constant primary current $\overline{OA}$. Any particular value $\overline{OK}$ of the primary electromotive force must be changed from $\overline{OK}$ to $\overline{OK^1}$ for constant potential, and all other magnitudes changed in the same proportion; that is, $\overline{OC}$ becomes $\overline{OC^1}$, $\overline{OD}$ becomes $\overline{OD^1}$. $\overline{OF}$ becomes $\overline{OF^1}$, etc., as already explained in the construction of other constant potential diagrams.

## The Calculation of Alternating Current Motors.—V.

BY E. ARNOLD.

In the last section of this article* equation (40) should read

$$M^2 = b^2 L_1 L_2.$$

A deduction from equations (31) and (33) is

$$D = \frac{s_2}{2} \cdot \frac{I_2^2 R_2}{p_1}; \qquad (53)$$

and as by neglecting the self-induction of the armature on account of leakage,

$$I = \frac{E_2}{R_2}, \text{ then also does}$$

$$D = \frac{s_2}{2} \cdot \frac{E_2^2}{p_1 \cdot R_2}. \qquad (54)$$

The last two equations indicate that the torque is equivalent to the energy absorbed by the armature $A_2$, divided by the angular velocity of the rotary field. Consider the number of pairs of poles of the motor $= K$, then the torque is $K$ times as great, provided the energy absorbed by the armature remains the same.

If for instance a 20-h. p. motor is to exert at starting a torque which corresponds to the torque of the motor at full speed, namely, an angular velocity about $= p_1 : K$, and full output, then, as $A_2 = D \cdot \frac{p_1}{K}$, the energy absorbed by the armature, taking into account the losses occurring in the motor, must be decidedly more than 20 h. p. So if we wished to secure an attractive moment a multiple of the normal torque, then we should have to supply to the motor many times the normal watt consumption.

With a large absorption of energy it is possible to keep the primary potential constant only when the capacity of the source of energy (be it transformer or generator) is very large as compared with the capacity of the motor.

If the capacity of the current source is but little greater than that of the motor, then in the case of motors constructed for a large attractive force the primary potential falls rapidly. This fall of potential is primarily due to the self induction, and by scattering of lines of force at the start, owing to the consequent great shifting of the phase between $I_1$ and $E_1$, the energy necessary for starting the motor can be supplied only by a great increase of current, amounting to many times the normal. This great increase of current causes another drop in potential directly, and also on account of the increased magnetic leakage. The E. M. F. can thus fall so low that in case of improper construction of the armature or the use of no special starting devices the motor may exert no pull whatever.

Therefore, in the construction of motors one must bear prominently in mind that the desired attractive force should be obtained with the smallest possible current. This last maintained requisite is particularly important for motors on lighting circuits.

The dependence of current $I_1$ upon other qualities is deduced from equation (50).

$$I_1 = \sqrt{\frac{8}{m^2 \cdot s_2} \cdot \frac{D\left[R_2 + \left(\frac{s_2}{2} \cdot p_1 L_2\right)^2\right]}{b^2 \cdot L_1 L_2 \cdot p_1 R_2}} \qquad (55)$$

We will distinguish two cases, namely:

1. When the resistance $R_2$ is small as compared with $p_1 L_2$; then we have, approximately:

$$I_1 = \sqrt{\frac{2 s_2}{m^2 b^2} \cdot \frac{D \cdot p_1 \cdot L_2}{L_1 R_2}} \qquad (56)$$

2. The reverse, where $R_2$ is large in comparison to $p_1 L_2$; then the result is about

$$I_1 = \sqrt{\frac{8}{m^2 b^2 s_2} \cdot \frac{D \cdot R_2}{p_1 L_1 L_2}}. \qquad (57)$$

From equations (56) and (57) it is apparent that to procure a certain torque the necessary current is less the greater the coefficient of self-induction, which means the smaller the resistance of the magnetic circuit in field and armature cores and air space and the less the magnetic leakage—that is, the larger $b$ is. The influence of $p$ and $R_2$ depends upon the relation of $R_2$ to $L_2$.

If the induced circuit consists of many windings of large section, then by the introduction of resistances in the different phases of the circuit, and by diminishing the frequency, the necessary current to produce a certain torque can be decreased.

If, on the contrary, the induced circuit consists of few thin wires of high resistance, then we have the opposite. The current necessary for the desired torque increases with increasing resistance and diminishing frequency.

Thus the resistance $R_2$ must be of an appropriate value for a given value of $L_2$ and a certain frequency, obviously that value of which an increase or diminution will alike cause an increase of the strength of the current $I_1$.

We can determine the value by equating equations (56) and (57).

Thus,

$$R_2 = \frac{1}{2} \cdot p_1 L_2 \cdot s_2 \qquad (58)$$

We can also arrive at the same result in the following manner:

Let $g$ designate the relation of the energy necessary to produce the rotary field to the energy consumed by the motor; then with $m$ primary, and $s_2$ secondary phases, we have, disregarding the losses due to hysteresis and Foucault currents:

$$g = \frac{A_2}{\frac{m}{2} \cdot R_1 I_1^2 + A_2}, \quad \text{or}$$

$$\frac{1}{8} = 1 + 12 \cdot \frac{R_1 R_2}{m^2 b^2 p_1 L_1 L_2 s_2} + 3 \cdot \frac{R_1 L_2 s_2}{m^2 b^2 L_1 R_2} \qquad (59)$$

Considering $R_2$ variable, then by differentiation we find that $g$ is a maximum for

$$R_2 = \frac{s_2}{2} \cdot p_1 L_2.$$

The efficiency $g$ of the motor at starting diminishes with decreasing resistance $R_1$ and increasing leakage, but becomes greater as $L_1$ and $p_1$ increase. The influence of the magnitude of $R_2$ and $L_2$ depends upon the relation of $R_2 : \frac{1}{2} s_2 p_1 L_2$.

If $$R_2 < \frac{1}{2} p_1 L_2 s_2$$

then the efficiency increases as $R_2$ increases, but if

$$R_2 > \frac{1}{2} p_1 L_2 s_2$$

it decreases as $R_2$ increases.

$R_2 = \frac{s_2}{2} p_1 L_2$ when starting the motor except with the use

Practically it is seldom possible to make the armature of switching devices; for, in the first place, the section of the wire would be so small as to cause excessive heating of the same, and, secondly, the torque would be too small for some purposes; for the greatest value of $g$ does not coincide with the maximum torque (see Fig. 8); this would be the case only when

$$\frac{1}{2} \cdot p_1 L_2 s_2 = R_1 \cdot \frac{s_2}{m} \cdot \frac{z^2}{s_1^2}$$

or when

$$2 \pi m \cdot p_1 s_1^2 = 10^9 R_1 \rho \qquad (60)$$

Complete motors, which I tested, constantly showed

$$2 \pi m \cdot p_1 s_1^2 > 10^9 R_1 \rho.$$

In explanation of the aforesaid I will cite a few experiments which have been carried out on motors of the Maschinenfabrik Oerlikon.

The magnetic attraction on a lever arm 11.5 cm. long on a four pole 10-h. p. motor was: (1) When the armature winding was made up of three phases ($s_2 = 3$) and 8 turns ($z = 8$) of 5 mm. wire per phase, with 32 volts, 230 ampères, it was 62 kg.; (2) when the armature winding consisted of three phases, each of 32 turns of 1 mm. wire, with 39 volts, 150 ampères, it was 64 kg.

A four-pole 3-h. p. motor gave the following pulls on a 6-cm lever: (1) With an armature winding of 36 closed circuited turns of 6 mm. diameter, with 73 volts, 120 ampères, it was 50 kg.; (2) with 36 closed circuited turns of 1 mm. diameter, with 75 volts, 15 ampères, it was 20 kg.

The coefficient of leakage, $b$, can be easily determined by experiment. From equation (50) it follows that for $K$ pairs of poles, when $R_2$ is small compared with $p_1$ and can be neglected,

$$D = \frac{m^2}{2} \cdot \frac{K \cdot b^2 s_1^2 \cdot I_1^2 \cdot R_2}{s_2 \cdot z^2 \cdot p_1} \qquad (61)$$

The torque is expressed in watts. If $h$ is the lever arm of the moment in metres, and $K$ the pull in kilograms, then

$$D = 9.81 \cdot K \cdot h \qquad (62)$$

If the torque is measured for a particular current $I_1$, then we can determine $b$ from these equations. The value varies with $I_1$.

I discovered that $b$ can be very small when the primary and secondary circuits remain fixed; 80 per cent. or more of the lines of force are lost by leakage.

The shifting of phase $\varphi_1$ in the primary circuit can be calculated from Fig. 9.

$$\cos \varphi_1 = \frac{I}{E_1}\left(R_1 I_1 + \frac{s_2}{2} \cdot p_1 M I_2 \cdot \cos \varphi_2\right) \text{ or}$$

$$\cos \varphi_1 = \frac{I_1}{E_1}\left(R_1 + \frac{m \cdot s_2}{4} \cdot \frac{p_1^2 \cdot M^2 R_2}{R_2^2 + \left(p_1 L_2 \frac{s_2}{2}\right)^2}\right) \qquad (63)$$

or approximately

$$\cos = \frac{I_1}{E_1}\left(R_1 + \frac{m \cdot b^2 \cdot s_1^2 \cdot R_2}{s_2 \cdot z^2}\right) \qquad (64)$$

From this equation we can arrive at some important conclusions. As I have just indicated, for instance, in the case of a 20 h. p. there must be an energy, $A$, of 20 h. p. supplied if it is to exert a torque which corresponds to the torque of the motor at full load, regardless of loss. Now as

$$A_1 = \frac{m}{2} \cdot E_1 I_1 \cos \varphi$$

then, in order to obviate the necessity of large currents, $\cos \varphi_1$ must be made as large as possible. As evident in equation (64), $\cos \varphi_1$ increases with $I_1$, $R_1$, $R_2$, and the transforming ratio $s_1 : z$, and diminishes with increasing leakage and with $E_1$. From this can be deduced various methods of starting multiphase motors, some of which have already been well adapted in practice.

1. When turning on the primary current a resistance without self-induction is switched in—that is $R_1$ is increased.

2. The resistance $R_2$ of the phase windings of the induced system is increased by inserting resistances free from self induction.

3. At starting, only a part of the secondary phase circuits are closed, the remainder being thrown in when the motor has reached full speed.

4. The transforming ratio $s_1 : s_2$ is made variable by increasing $N_1$ or diminishing $N_2$, or by doing both at the same time.

5. The relation $J_1 : E_1$ can be changed by putting a transformer with variable transforming ratio in the primary circuit. When starting the motor the transformation is made such that the relation $J_1 : E_1$ is as large as possible.

6. By combination of the cases (1) to (5) there will result other methods of starting. For instance, the induced part can be equipped with two windings, and at starting the winding with high resistance and large transforming ratio is used, the one of lower resistance being afterward switched in.

Concerning the practical worth of these methods of starting I will have more to say later.

An armature on which all bars are short circuited on the circumference would give the highest transforming ratio, but at the same time $R_2$ would be small and $s_2$ large.

If it is not to be feared that with the correct resistance the heating will be too excessive, then such an armature would give good results.

DETERMINATION OF THE ENERGY $A_1$.

$$A_1 = \frac{m}{2} \cdot E_1 \cdot I_1 \cdot \cos \varphi_1$$

with the substitution of the value of $\cos \varphi_1$ from equation (63)

$$A_1 = \frac{m}{2} \cdot R_1 I_1^2 + \frac{m^2}{8} \cdot \frac{p_1^2 \cdot M^2 \cdot I_1 \cdot R_2 \cdot s_2}{R_2^2 + \left(\frac{s_2}{2} \cdot p_1 L_2\right)^2} \qquad 65$$

The first member gives the energy absorbed in the primary and the second member gives that absorbed in the secondary winding. As the motor performs no work all the energy $A_1$ is converted into heat. The second member represents the value of $A_2$, and is $= p_1 D$ according to equation (50).

## The Capacity Required to Most Nearly Neutralize Self-Induction at Any Frequency of Alternation.

BY ALBERT C. CREHORE.

It is often desirable in dealing with alternating currents of electricity to know, without stopping to make the calculation, just what capacity is required to most nearly neutralize a given self-induction when the current has a given frequency; or, on the other hand, to know what self-induction will most nearly neutralize a given capacity at the frequency used. Again the question may be to find what frequency would be required to most nearly neutralize some given self-induction and capacity.

Any of these questions may be answered immediately by referring to the accompanying figures without making any numerical calculation. The value obtained will be sufficiently accurate in most cases so that if an approximate value is all that is needed, no calculation at all is required. Moreover, the graphical representation presents to the eye at once just the relation between these three quantities concerned, viz., frequency, self-induction and capacity, and shows what changes are required in the remaining two quantities, if one alone is varied.

It is well known that for alternate current flow in a circuit, where the current is strictly harmonic, there is a law analogous to Ohm's law for steady currents. If we substitute for the steady current of Ohm's law either the maximum or square root of mean square value of the periodic current, and for the steady electromotive force the maximum or square root of mean square value of the periodic electromotive force, while the ohmic resistance is replaced by the impedance, we may write Ohm's law:

$$\text{Constant Current} = \frac{\text{Constant Electromotive Force}}{\text{Resistance}} \qquad (1)$$

The analogous law for harmonic currents is

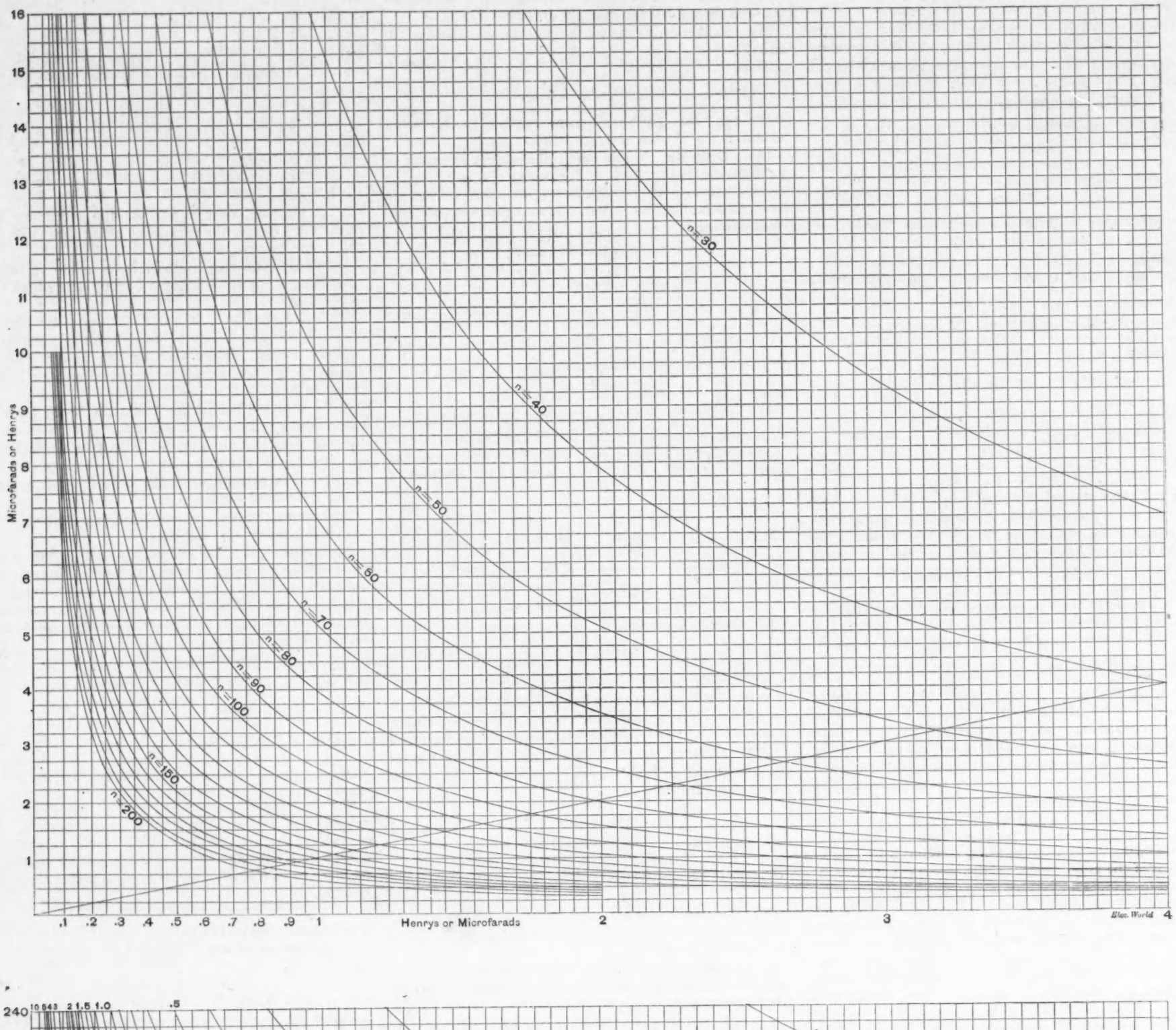
$$\left.\begin{matrix}\text{Maximum harmonic} \\ \text{current}\end{matrix}\right\} = \frac{\text{Maximum Harmonic E.M.F.}}{\text{Impedance.}} \qquad (2)$$

or

$$\left.\begin{matrix}\text{Square root of mean} \\ \text{square of harmonic} \\ \text{current}\end{matrix}\right\} = \frac{\text{Square Root of Mean Square of the Harmonic E.M.F.}}{\text{Impedance.}}$$

In symbols, letting $E$ and $I$ denote either a steady E. M. F. current or maximum, or mean square root of mean square value of the same for harmonic currents, while $R$, $L$, $C$ and $\omega$ stand for the resistance, the coefficient of self-induction, the capacity and $2\pi$

* See THE ELECTRICAL WORLD Dec. 9, 1893, page 444.







FIGS. AND 2.—CURVES SHOWING THE CAPACITY THAT NEUTRALIZES SELF-INDUCTION IN PARALLEL OR IN SERIES AT DIFFERENT FREQUENCIES

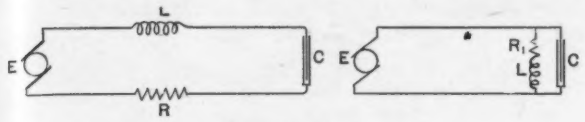
times the frequency respectively, we may write Ohm's law for steady currents:

$$I = \frac{E}{R} \qquad (4)$$

The analogous law for harmonic currents, where the capacity and self-induction are in series, is:

$$I = \frac{E}{\sqrt{R^2 + \left(\frac{1}{C\,\omega} - L\,\omega\right)^2}}. \qquad (5)$$

Fig. 3 illustrates what is meant by capacity, and




FIGS. 3 AND 4.

self-induction in series in distinction from Fig. 4, where they are represented as in parallel.

If the values of $L$, $C$ and $\omega$ are so related that the expression $\frac{1}{C\,\omega} - L\,\omega$ under the radical reduces to zero, then evidently the current flow by the analogous law would be the same as that given by Ohm's law; and the current would thus be the same as if the capacity and self-induction were absent. We are thus led to speak of a capacity neutralizing a self-induction when, although they are present, the current flow is the same as if they were absent. And it is this relation that must exist between the quantities $L$, $C$ and $\omega$ before such neutralization takes place, viz.:

$$\frac{1}{C\,\omega} - L\,\omega = 0. \qquad (6)$$

This may be written in a variety of ways all of which express the same thing, thus:

$$\omega = \frac{1}{\sqrt{L\,C}} \qquad (7)$$

$$L\,C = \frac{1}{\omega^2} \qquad (8)$$

It should be remembered that unless the current is strictly harmonic it will not be possible to neutralize completely any self-induction by capacity, but with an ordinary alternating current which is not strictly harmonic this relation may in some cases give almost complete neutralization, while it gives as near an approach to neutralization as any other relation.

If the unit of self-induction, $L$, in the above expression is the henry, the corresponding unit of capacity, $C$, which satisfies the equation is the farad. The farad is too large a unit for practical purposes, and the microfarad, which is $\frac{1}{10^6}$ part of a farad, is more nearly adapted for the practical unit. If microfarads and henrys are the units, we may introduce the factor $10^6$ into the equation, and write:

$$L\,C = \frac{10^6}{(2\,\pi\,n)^2} \qquad (9)$$

where $n$ denotes the frequency.

If we assume that the frequency is 100 alternations per second, the right hand member of (9) is a constant equal to 2.533 approximately, and the equation may be written:

$$L\,C = 2.533. \qquad (10)$$

Referring to Fig. 1, let the abscissae represent values of $L$ in henrys and the ordinates values of $C$ in microfarads. Twenty squares horizontally are one unit, and four squares vertically is one unit. The plot of equation (10) will give the curve labeled $x = 100$, which is an equilateral hyperbola having the axes of $L$ and $C$ as asymptotes.

In a similar manner to that indicated curves have been drawn for different values of $n$ increasing by tens from 30 to 200.

Consider an example: For a frequency of 150 what capacity will most nearly neutralize a self-induction of .4 henrys? Look along the horizontal axis for .4, then run vertically up from the .4 mark till we come to the curve labeled $n = 150$, and read on the vertical scale a little more than 2.75 microfarads. Upon calculation we find the correct value by the formula is 2.8 microfarads.

Since the equation expressing this relation is exactly the same in form if $L$ and $C$ are interchanged, we may read off $C$ on the axis of abscissae and $L$ as ordinates. We obtain the same result for the last problem; for example, if we ga on the vertical axis to .4, and then go horizontally to the right until we meet the line marked $n = 150$, we meet it at 2.8. In this manner, since there is a choice of two places on each curve which may be consulted, that place may be chosen which will give the most accurate reading.

Then by this means we may increase the range of the diagram. For example, suppose a case where the frequency is 100 and the self-induction 10. This is obviously out of range for $L$ on the horizontal axis, but by reading $L$ on the vertical axis we find that $C = .25$. This, it will be seen, is nearly correct by referring to equation (10) and substituting $L = 10$. The straight line crosses the curves in Fig. 1 at the points where the self-induction is numerically equal to the capacity.

Referring again to equation (9), we may write it in either of the forms,

$$L\,n^2 = \frac{10^6}{(2\,\pi)^2\,C} \qquad (11)$$

Or

$$C\,n^2 = \frac{10^6}{(2\,\pi)^2\,L} \qquad (12)$$

If we assume that $C = 1$ microfarad and wish to investigate the relation between $L$ and $n$ we have the equation:

$$L\,n^2 = \frac{10^6}{(2\,\pi)^2} = 25330. \qquad (13)$$

Let the abscissae, Fig. 2, represent values of $L$, and the ordinates values of $n$; equation (13) will then give the curve labeled 1 microfarad or henry. This curve is not a conic section, as were those in Fig. 1, but here we have a curve whose equation is of the third degree. If, on the other hand, we put $L = 1$ in equation (12) we find that

$$C\,n^2 = 25330, \qquad (14)$$

an equation identical with (13) if we replace $C$ by $L$. We should then obtain the same curve labeled 1 microfarad or henry, if we use the same units on the axis of abscissae for $C$ as we did formerly for $L$. Hence we may use the same set of curves, whether the horizontal axis is for $L$ or for $C$. For example, take the curve labeled .7, and consider it to mean .7 microfarad, then we may read off henrys on the horizontal axis. But, if we consider that .7 means henrys, then we may read off microfarads upon the horizontal axis.

Let it be required to find at what frequency .7 henry will neutralize 2.5 microfarads. Selecting the curve marked .7, observe that at a distance of 2.5 horizontally to the right of the origin the ordinate gives just 120, the required frequency. The same result should be obtained if we select the curve marked 2.5, and go to a distance .7 horizontally to the right. We find that the result is as before, 120. Since this result comes out an even 120 we may verify it by reference to Fig. 1 where there is a curve given for 120, and we do not need to interpolate.

Let it be required to find what capacity with a frequency of 155 will just neutralize 2.3 henrys. Referring to Fig. 2, and measuring 2.3 horizontally and 155 vertically we arrive at a point between the curves labeled .4 and .5. Upon estimating the number of hundredths by judging the relative distance of the point from each curve, .4 and .5, and remembering that the curves grow gradually nearer together as we go from .4 to .5, we judge that the value of $C$ is .46 approximately. This value may now be tried by measuring off horizontally .46 and going up to the 155 line vertically. The point arrived at should lie upon the 2.3 curve if 4.6 is the correct value; and by estimating the distance between the two adjacent curves we may verify the result before obtained.

Interpolated values may be obtained quite accurately in the following manner: In the first place it is to be noticed that if the curve labeled 1 were given, the curve labeled 2 could be constructed from it very easily; for, with any given ordinate, as 80, for example, the abscissa of curve 2 is 2, being exactly one-half as much as the abscissa of curve 1, which, in this case, is 4. Similarly each abscissa of curve 2 is one-half as much as the abscissa of curve 1 corresponding to the same ordinate. And generally a curve labeled $x$ might easily be constructed from curve 1 by simply making the abscissa of the new curve, corresponding to the same ordinate, bear a ratio of $\frac{1}{x}$ to that of curve 1. Thus the curve labeled .5 has its abscissae twice as great as that of curve 1, for the same ordinate.

Since there are always two places where we may try our values to obtain a result it leads to a method of obtaining a new curve from those already drawn. Suppose it were desired, for instance, to draw the curve labeled 1.5. Since the ordinate at a distance 2 horizontally to the right crosses the 1.5 line at the same height that the ordinate 1.5 to the right crosses the 2 line, it follows that the curve labeled 1.5 may be constructed by observing where the vertical line 1.5 units to the right of the origin crosses the various curves already drawn. For instance, the 1.5 vertical line crosses the curve 5 at a height of 58. Lay off, then, on the ordinate 5 units to the right, a height of 58. This will be one point of the 1.5 curve. Following up the 1.5 ordinate again, it crosses the 4 curve at a height of 65. Measuring up a height of 65 upon the ordinate 4 units to the right, we find a second point of the 1.5 curve. Thus enough points may be found to enable us to draw the curve 1.5.

To return to the case of interpolation already considered, we may interpolate the value of $C$ corresponding to $L = 2.3$ and $n = 155$ as follows: We estimate the value of $C$ as .46. The .46 curve may be easily drawn near the point in question by finding only two points on the curve in the manner indicated. Observe where the 2 and 2.5 curves cross the .46 vertical, and lay down these observed heights upon the 2 and 2.5 ordinates respectively. This gives two points upon the .46 curve in the neighborhood of the desired value and shows the reading .46 to be nearly correct. The correct value being .4585 approximately, as calculated from the formula.

A little practice will enable one to interpolate quite accurately when necessary and it will take but a moment to do so by the method indicated. If either of the given values $L$ or $C$ is an even number for which a curve is drawn, that curve may be selected for the even number, and the other number may be read off on the horizontal axis, whether it be even or not, so that no interpolation is necessary. For example, what frequency is required to neutralize 1.8 henrys and 2.35 microfarads? There is a curve drawn for 1.8. Reading the ordinate of this curve 2.35 to the right we read $n = 78$, the required frequency.

### A CONDENSER IN PARALLEL WITH SELF-INDUCTION.

The preceding remarks have applied apparently only to that case where a condenser was placed in series with self-induction, but it is true that they will apply whether we have the condenser shunted around the self-induction or placed in series with it. Generally we may say that the result obtained by neutralizing capacity and self-induction is to bring the difference in phase between the impressed electromotive force and the current to zero, so that they have the same direction. The diagram for the case of a condenser shunted around self-induction will make this more clear. Let the circuit be that represented in Fig. 4, where $C$, $R$ and $L$ mean the capacity, resistance and self-induction, found in the branches as represented. The geometrical diagram is seen in Fig. 5. Here $\overline{OA}$

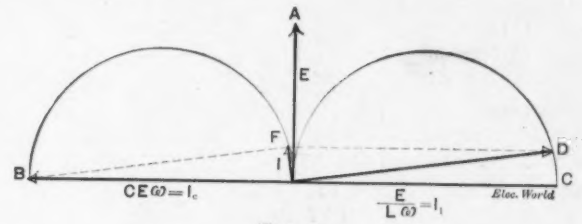



FIG. 5.

represents the impressed electromotive force at the points $M$ $N$, Fig. 4. The current in one branch is entirely independent of that in the other and depends solely on the impressed electromotive force at the terminals $M$ $N$. If we have self-induction in one branch it will cause a lag of the current behind the electromotive force $\overline{OA}$. This current is represented at $\overline{OD}$, and the tangent of the lag $AOD$ depends merely upon the ratio $\frac{L\,\omega}{R_1}$. If $R$ is varied, this angle $AOD$ varies, and so does the magnitude of $\overline{OD}$. It has been shown* that this point $D$ moves upon the semi-circle $ODC$, upon $OC$ as diameter, as the resistance is varied, and even though the resistance could be reduced to zero, still the self-induction would prevent an infinite current from flowing. The maximum current that may flow is then $\overline{OC}$, and it is equal to $\frac{E}{L\,\omega}$, and is 90 degrees behind the impressed E. M. F. $\overline{O\,A}$.

Considering the condenser branch, the current in it will be in advance of $\overline{OA}$, the electromotive force, by the angle whose tangent is $\frac{1}{C\,R_c\,\omega}$. But as we consider that $R_c$ is very small and negligible this angle is almost exactly 90 degrees in advance of $\overline{OA}$, and is represented at $\overline{OB}$. In a similar manner the condenser prevents an infinite flow of current in its branch, even though the ohmic resistance is very small; and the magnitude of $\overline{OB}$, the condenser current, is $C\,E\,\omega$.

The current in the main line is the geometrical sum of the two branch currents. In the case supposed, if we could make the resistance of each branch very small, the branch current $\overline{OB}$ and $\overline{OC}$ would be in exactly opposite directions, and the geometrical sum would be the arithmetical difference of the currents. If we call $I$ the main current,

$$I = C\,E\,\omega - \frac{E}{L\,\omega} = E\left(\frac{1}{C\,\omega} - L\,\omega\right) \qquad (15)$$

If the relation

$$\frac{1}{C\,\omega} - L\,\omega = 0$$

exists, the main current would be zero, while the branch currents might be quite large. This would, of course, be an ideal case, for we could not in practice reduce the resistance in the branch containing self-induction so low. But, when the resistance increased from a small value, the induction current moves along the semi-circle $CDO$, and the resultant current in the main line, being the sum of $OD$ and $\overline{OB}$, moves along the semi-circle $OFB$, and is almost in phase with the impressed electromotive force $\overline{OA}$ when the resistance of the induction branch is small compared with the inductance. A comparatively large current in the shunt branches may be obtained in this manner from a small main line current. The relations represented by the curves in Figs. 1 and 2 are the essential ones whether the self-induction and capacity are jointed in series or in parallel.

* See "Alternating Currents," page 309, Bedell and Crehore.

# THE ELECTRICAL WORLD'S DIGEST OF CURRENT TECHNICAL ELECTRICAL LITERATURE.

(Compiled from the principal foreign electrical journals.)

BY CARL HERING.

ELECTRO-PHYSICS.

*Conductivity of Dielectric Liquids.*—The "Phil. Mag." for December reprints a short note by Koch, mentioned in the Digest last week; he describes a method which he found very satisfactory; it consists of a Dewar form of capillary electrometer, in which the electrolyte is the liquid itself to be investigated; all dielectric liquids without exception when thus investigated exhibit polarization, but he thinks it probable that in the case of benzole, for instance, it is due to the presence of impurities, describing another experiment showing that when in its greatest purity benzole showed no polarization, even with high E. M. F's., and it appears to be a perfect insulator; moisture appears to be one of the principal impurities.

*Propagation of Electro-magnetic Waves.*—According to the Lond. "Elec. Eng.," Dec. 8, Dr. Riley, in a recent lecture, referred to the researches of Hertz, stating that he had proved experimentally that the waves were transmitted with a velocity of about 185,000 miles per second; he states that light waves are undoubtedly electro-magnetic waves, and that Hertz had confirmed the theories of Maxwell.

*Reflection of Electric Waves at the End of a Conductor.*—The Lond. "Elec.," Dec. 8, publishes, with illustrations, a translation of the article by Sarasin and de La Rive, mentioned in the Digest, Dec. 16.

*Waves in Electrolytes.*—The "Phil. Mag." for December contains an article by Mr. Yule, describing at some length researches on the passage of electric wave trains through layers of electrolytes, made with the advice and suggestions of Prof. Hertz.

*Oscillation.*—Mr. Blondin's mathematical article on "Oscillations and Cylindrical Conductors," mentioned in the Digest Dec. 9, is continued at some length in "La Lum. Elec.," Dec. 2.

*Interference of Waves in Air.*—"La Lum. Elec.," Dec. 2, reprints the first part of an article by Messrs. Klemencic and Czermak from "Wied. Ann," vol. 50, p. 174.

*Multiple Resonance.*—"La Lum. Elec.," Dec. 2, reprints from the "Jour. de Phys." an abstract of an article by Mr. Garbasso.

*Vacuum Tubes.*—Sir David Salomons, in the Lond. "Elec.," Dec. 8, in referring to his previous communications (see Digest, July 15 and 22), states that in his opinion the phenomenon of dissociation in vacuum tubes is simply a question of interference and is comparable to, if not actually identical with, Newton's rings; Tesla's experiments are claimed to confirm this view.

*Heat Radiation.*—In an editorial in the Lond. "Elec. Rev.," Dec. 8, attention is called to a recent Paris Academy paper by Mr. Violle, in which he found that a number of substances which are chemically very different present exactly the same brilliancy and act equally upon the eye, and upon a photographic plate when heated in the arc, showing that all these substances are in an equilibrium of radiation according to Kirchhoff's laws.

*Heat Generated in Electrolytic Cells.*—The Lond. "Elec. Eng.," Dec. 8, reprints a scientific paper by Mr. Allan, read before the Physical Society of Glasgow University.

MAGNETISM.

*Elongation Produced by Magnetism.*—The "Phil. Mag." for December contains a communication by Mr. Lochner, of Worcester, Mass., in which he gives figures and curves obtained from a series of investigations intended to confirm the apparently contradictory results of Berget and Bidwell, and resulting in an experimental verification of both. His conclusions are as follows: They confirm the general form of Bidwell's curves; they indicate that the expansion is a function of the ratio between the diameter and the length, and that the elongation varies directly as possibly the square root of this ratio; they indicate that the expansion varies directly as the permeability; that the current for the maximum expansion and for the point of no expansion depends upon this ratio; there are two maxima, one for an increasing current and another by decreasing the current from the first maximum; the first contact gives more expansion than the second and the following contacts, the expansion falling off with subsequent contacts.

A translation is published in the Lond. "Elec.," Dec. 8, including one of the cuts; in an editorial it is suggested that the rotation of the iron molecules on their axis may account for the increase in length, and that on the other hand the mutual attractions between the adjacent molecular poles would tend to shorten the distances between them; the two effects would occur simultaneously, the former producing the greater effect at first while the latter would become more marked when the iron approached a higher degree of magnetization.

*The Pull of Magnets.*—In an editorial in "Ind. and Iron," Dec. 8, J. S. discusses several different points of view from which the pull of electromagnets may be considered; the first appears to be of theoretical interest only; the next is to find the induction and square it, giving the pull per centimetre, the pull being proportional to the square of the induction, and as the air space is supposed to be small, this pull per square centimetre is multiplied by the area to get the total force; in the third method find the energy stored up in the system, then let the armature move toward the magnet, thus putting in more energy, then short-circuit the cell which is exciting the magnet, thereby getting out a certain amount of energy; then the difference of the energy put in and taken out electrically is the sum of the first two less the third, and as this can be calculated and the work done on the armature can be calculated, a numerical example is promised in the next installment.

UNITS, MEASUREMENTS AND INSTRUMENTS.

*Resistance.*—The Siemens and Nebel resistance consisting of an open spiral packed in sand in an iron tube enameled on the inside is illustrated in "La Lum. Elec.," Dec. 2.

*The Continuous Current Arc as a Standard of Light.*—The translation of Mr. Blondel's Congress paper is continued in the Lond. "Elec.," Dec. 8.

*Meter.*—"La Lum. Elec.," Dec. 2, describes and illustrates the Dejardin meter.

*Measuring Instruments.*—In Messrs. Niblett and Ewing's serial in the Lond. "Elec. Eng.," Dec. 8, the subject of verniers is discussed.

DYNAMOS AND MOTORS.

*Commutation in Motors and Dynamos.*—The Lond. "Elec.," Dec. 8, contains a well illustrated article of Mr. Kingdon, in which he shows that there is a real difference between motors and dynamos, which appears to have been overlooked; this difference is in the process of commutation in the armature and in the effect of the reversal of the current in the coils under the brushes upon the magnetic field; he illustrates his argument with the aid of a number of diagrammatic illustrations and arrives at the following conclusions: "In a motor the armature rotation tends to increase the aggregate magnetomotive force of the field and armature coils, and to strengthen the magnetic field; in a dynamo the armature rotation tends to reduce the aggregate magnetomotive force and to weaken the field; in a motor the effect of commutation is to tend to reduce the aggregate magnetomotive force and to weaken the field"; in a dynamo the effect of commutation is to tend to increase the aggregate magnetomotive force and to strengthen the field. Iron is very sensitive to slight increases of magnetomotive force, while, on the other hand, it is comparatively insensible to considerable reductions of the magnetomotive force; in dynamos, therefore, it is much more necessary to have special arrangements for commutating the current so as to avoid sparking.

*Theory of Rotary Field Motors.*—In "La Lum. Elec.," Dec. 2, Mr. Leblanc criticises the article of Mr. Farman (see Digest, Dec. 9), in which he denies the correctness of one of the formulas; among other things he also states that, contrary to Mr. Farman's assumption, in all good machines the coefficients of self-induction of the circuits are constant. Mr. Farman replies to the first criticism, showing that Leblanc's assumption is incorrect; to the latter Mr. Leblanc again replies.

ARC AND INCANDESCENT LIGHTS.

*Cost of Gas and Electric Light.*—The Lond. "Elec.," Dec. 8, makes some interesting deductions based partly on recent tests of gas burners made under the auspices of Prof. Ayrton. A set of curves is given for four different burners showing the relation between pressure and cost per candle per year, all of which show a minimum for the cost. In comparing gas lights with electric lights, attention is called to the fact that the efficiency depends largely on the size of the burner, but that no such difference exists with incandescent lamps, while, on the other hand, a gas burner has a long life while an incandescent lamp has not. A graphical representation of the results is given in the form of lines of different lengths representing the costs for different burners and incandescent lights. In order to compete with the average gas burner with gas at about 65 cents, a 16 c. p. incandescent lamp must run at nearly 2½ watts per candle, and at the rate of about 10 cents per kilowatt-hour.

*Filament.*—The "Elek. Tech.," Nov. 30, mentions a new patent of Mueller, in which the filaments are made of a very thin metallic wire, best made of two parts of fine cast iron with one part of aluminium; this is very porous, sufficiently ductile when properly annealed and already contains carbon, besides being a poor conductor; the fine wire is first treated in a heavy liquid hydrocarbon, having a high boiling point, in which the filament absorbs the liquid; after being bent into shape it is covered with a layer of carbon by being dipped in pitch, dissolved in alcohol, to which graphite or lamp black has been added; after drying by pressing a weak current through the wire, it is placed in a receptacle connected with an airpump and retort, the latter containing a warm hydrocarbon; a strong current is then passed through it which deposits a layer of carbon. (This appears to be somewhat similar to the well-known Cruto process, in which a fine platinum wire was treated in a hydrocarbon.)

*Diffusers.*—Mr. Haubtmann continues the discussion of the Fredureau diffusing globes in "L'Elec.," Dec. 2; the present portion is devoted to a mathematical discussion of the optical features.

TRANSMISSION OF POWER.

*Transmission of Power at Niagara Falls.*—The last portion of the discussion of Prof. Forbes' paper is given more fully in the Lond. "Elec. Rev.," Dec. 8, than in the journals from which the abstract in the Digest last week was taken; from this the following additional abstracts are taken: Mr. Morley does not agree that one of the greatest advantages of low frequency is in connection with the line conductors; he discusses at some length the so-called Hughes effect, showing how very slight it would be in this case, even at higher frequencies; he doubts whether it is worth the while to lower the frequency to that extent in order to obtain such a very slight gain in the line; regarding the transformers he does not agree with Forbes, stating that it was impossible by any amount of money, space, time or thought to make a transformer anything like as good at a low frequency as at a high, it was not a question of design or money; it was a great mistake to think that a transformer could be designed to be equally good under any given set of conditions as far as periodicity was concerned, as it was not possible; he called attention to the fact that Forbes had cut himself off from the possibility of using a commutated current, because the lights would flicker; for lighting purposes he must always transform to a higher frequency or to direct current; regarding the question of regulation in multiphase working, he states that he believes it to be merely a question of design and that with a reasonably straight characteristic there would be no bad effect; "ordinary dynamos that had a curve that went down like the Falls of Niagara were unsuited for this kind of working." Mr. Kapp agreed with Mordey regarding the transformers; referring to the calculation at the end of Forbes' paper he agreed with the 42 per cent., but feared that it had been overlooked that with a high frequency 2½ times the E. M. F. would have to be supplied, and what appeared to be an increase in the loss of 42 per cent. became actually a gain of 33 per cent., showing that the high frequency motor was the more efficient; regarding the starting of alternate current motors he calls attention to the ingenious arrangement now used all over the Continent, consisting of an auto-transformer, with a switch handle, which transformed down to a low voltage for starting the motor, an arrangement which worked very satisfactorily; he thinks there are very strong reasons against adopting low frequency for motors and also, though to a less extent, for transformers; regarding the proposed dynamo he stated that no alternator so light for the output had ever before been designed. Prof. Silvanus Thompson disputed the point that the lower the frequency the more efficient and sure is the parallel working; he discussed at some length several points regarding parallel working.

*Transmission of Power at Biberist.*—The "Rev. de L'Elec.," Nov. 30, gives figures regarding the efficiency of the transmission in this plant, from which we take the following: The distance is 17.2 miles, which is the longest of any plant in Switzerland; 262 horse power are transmitted by continuous currents at an efficiency of 72 per cent.; the voltage is from 5,000 to 6,600; the efficiency of the line is about 85.6 per cent., that of the generator 92 per cent. and that of the motor about 91 per cent.

*Transmission of Power*—Prof. Unwin's fifth lecture is concluded and his sixth one begun in the Lond. "Elec. Eng.," Dec. 8. His sixth lecture, which includes gas and electricity, was abstracted in the Digest, Dec. 2.

ELECTRIC RAILWAYS.

*Accumulator Cars in Paris.*—The Lond. "Elec. Eng.," Dec. 8, gives a short description, accompanied by a number of working drawings, of the accumulator cars used in Paris, taken from "Rev. Industrielle." After trying gearless motors the single-reduction gear was decided upon; there are 108 cells having a total weight of 2½ tons; the motor (with steel pole pieces) and car weigh 1½ tons.

*Starting Railway Motors.*—The Lond. "Elec. Rev.," Dec. 8, contains a short discussion regarding Kapp's flywheel reservoirs, as compared with the use of storage batteries; the editors of that journal claim that the only direction for improvements is to be looked for in a rational use of storage on the cars or by transformers.

*Cost of Traction.*—In an article by Mr. Kummer, reprinted in the "Zeit. fuer Elek.," Dec. 1, he compares in detail the cost of horse and electric traction, based on German prices.

*Mining Locomotive.*—Lond. "Elec. Ind.," Dec. 1, gives a short illustrated description of a new Schuckert locomotive used in German coal mines.

CENTRAL STATIONS, PLANTS, SYSTEMS AND APPLIANCES.

*Two-phase System.*—The fifth section of Mr. Kennedy's serial is contained in the Lond. "Elec. Rev.,"

Dec. 8; he discusses central stations and sub-stations, giving a general diagram of the connections; the general arrangements have already been described in these abstracts. He calls attention to the form of the curve of the current, stating that the one which gives the best results is the true sine curve, which is obtained from but few alternators, among which he mentions Kapp's; the dynamo proposed by Mr. Kennedy, already described, and which he calls the "Universal" dynamo, he states would have given the best results if used in the Niagara Falls station; there are at least four different and new methods of converting quadrature currents into continuous currents, the best one of which he cannot describe at present, but promises to do so later; he claims to have been the first to advocate in 1886-87 the use of low voltage generators, with step-up transformers, and that the transformers which were illustrated at that time are still the best for the purpose; an illustration is given showing a large number of coils, each surrounded with iron, the wire of both primary and secondary being alike in number of windings and size of wire, the coils being coupled in parallel and in series to obtain different ratios of transformation.

*Polyphase Currents.*—The article mentioned in the Digest, Dec. 9, is continued in the Lond. "Elec. Eng.," Dec. 8; alternate current motors are classified and discussed, the greater portion being devoted to an analytical discussion of the theory of the rotating field; it appears to contain nothing new.

*Motive Power in Gearing.*—Mr. Carter's serial is continued in the Lond. "Elec.," Dec. 8; the present section is devoted entirely to mechanics, chiefly to inertia and moment of inertia.

*Fire Risks.*—The "Elek. Echo," Dec. 2, reprints the first portion of a paper by Mr. Wilke, in which he classifies and discusses fire risks in electrical installations.

*Regulations for Electric Lighting on Ships.*—The "Zeit. fuer Elek.," Dec. 1, reprints the regulations from "Lloyd's Register of British and Foreign Shipping" for May.

*Gas Engine Accumulator Stations.*—A translation is given in abstract in the Lond. "Elec. Eng.," Dec. 8, of the article mentioned last week.

*Fuel Economy.*—The Lond. "Elec. Rev.," Dec. 8, contains a communication by Mr. Granger.

*Statistics, France.*—According to "Sciences et Commerce," France, outside of Paris, has 317 stations and 47 projected or in course of construction; the total horse power is 35,000, of which two-thirds is produced by steam and the rest mostly by hydraulic power, a few thousand horse power being generated by gas; in only 40 stations the alternating current is used, in seven both continuous and alternating currents, and in the others continuous currents are used.

*Bockenheim.*—Almost the entire issue of the "Elek. Zeit.," Oct. 27 (just received) is devoted to a lengthy and well illustrated description of this station, by Mr. Uppenborn. A brief description was given in the Digest Sept. 16, and references Sept. 23 and Nov. 4; the three-phase system is used in connection with accumulators, the plant being run only during the day.

*Dieppe.*—"La Lum. Elec.," Dec. 2, gives an illustrated description of this new station, in which the three-wire system with accumulators is used; the illustrations include a diagram of the switchboard with connections and some details of the station.

*Edinburgh.*—The report of Prof. Kennedy for the proposed plant for this city is given in the Lond. "Elec. Rev.," Dec. 8.

*Cape Town.*—The Lond. "Elec. Rev.," Dec. 8, mentions briefly the prospective station of Siemens & Halske.

*Fuerstenfeld-Bruck.*—"La Lum. Elec.," Dec. 2, gives a brief description of this station, including a number of cuts.

WIRES, WIRING AND CONDUITS.

*Regulations for Lines on Public Streets.*—The rules and regulations issued by the French Government are given apparently in full in the "Bul. Soc. Int. des Elecs." for November.

*French Cable Trust.*—The Lond. "Elec. Rev.," Dec. 8, announces that the three most important cable manufacturing companies in France have entered into a combination.

*Networks of Conductors.*—Mr. Coltri's article mentioned in the Digest Dec. 16, is continued in "La Lum. Elec.," Dec. 2.

TELEGRAPHY, TELEPHONY AND SIGNALS.

*Telephone Newspaper.*—In the "Elek. Tech.," Nov. 30, Mr. Vodicska gives some additional information regarding this installation, which was described in the Digest March 18 and Nov. 4. He calls attention to the importance of preventing the subscribers from talking with each other, and suggests two arrangements, one of which is to have a large number of transmitters, one for each subscriber, all arranged close to the speaker, and the other is to have a separate induction coil for each subscriber and connecting them all to a common transmitter; it is best to connect all the primary windings in series, although they may also be connected in parallel or multiple series.

*Clamond Telephone.*—"La Lum. Elec.," Dec. 2, gives several illustrations of this telephone as constructed in practice; the principle was described and illustrated in the Digest Feb. 4; it consists essentially of a variable contact made of plastic material, which is variably compressed by the vibrations of the diaphragm; the plastic material is made of glycerine or vaseline and a metallic powder which is as light as possible, as for instance, aluminium filings or dust; the plastic material in the form of a cylinder between two contact plates is enveloped by a thin flexible tube, made of rubber applied in a liquid form by means of a brush.

*Self-Induction and Static Discharge.*—In an editorial in the Lond. "Elec. Rev.," Dec. 8, the supposed advantages of a low specific insulation resistance in increasing the speed of signaling are discussed briefly, and it is claimed that in many cases the conditions of working made it very doubtful whether the improved working was not due to some cause in no way connected with low insulation; it is suggested that the question might readily be settled by experimenting with artificial cables in which a number of leaks are inserted; less theorizing and more experimenting, it is thought, might soon clear up the mystery.

ELECTRO-CHEMISTRY.

*Electrolysis.*—Regarding the query published in The Electrical World, Nov. 18, page 396, Prof. C. V. Boys writes to the Lond. "Elec.," Dec. 8, that the "experiment was in effect made in the year 1880 (Phil. Mag., November, 1880), when the late Dr. Guthrie and I made comparative measures of the conductivity of liquids in which the currents were induced by a moving magnetic field, there being no electrodes. Of course there is no evolution of gas and no effective decomposition."

*Electric Disinfectant.*—Basing its opinion on an account in the London "Standard," the Lond. "Elec.," Dec. 8, states that the hygienic value of the Hermite process of sanitation is one of considerable importance; "the deodorizing and bacillus-slaying propensities of electrolyzed salt water appear to be both prompt and perfect. From the experiments now being carried out at Lorient, it would appear that the worst kinds of sewage may be allowed, after passage through the Hermite syphon, to flow in an open drain along the public street with every appearance of being a limpid and colorless stream of pure water. It is also stated that some of the fever dens of Lorient have been appreciably improved by an application to them of this electrolytic process. It seems that there are two classes of bacilli, those which like oxygen and those which do not like it; but neither appears to like electrolyzed sea water."

*Electrolysis of Fused Salts.*—Mr. Andreoli begins an article on this subject in "Ind. and Iron," Dec. 8; he gives a brief review of the history stating that now it is a well known fact that the saving effected by the electrolytic method in the manufacture of bleaching powder and caustic soda is 50 per cent.; the electrolysis of fused salts, however, he considers a great deal more important, and thinks in many instances it will supplant the electrolysis of solutions; on a small scale chlorine and soda are obtained far more advantageously from fused chloride of sodium than from its solution, and he thinks that the electrolysis of fused common salt will be the sole, cheap, efficient and commercial source of chlorine and alkali in the future.

*Production of Alkalies.*—"La Lum. Elec.," Dec. 2, describes briefly the apparatus of Mr. Despeissis, in which the tank is divided into two compartments by a partition extending nearly to the bottom and containing a layer of mercury, thus forming a metallic diaphragm between the two parts; the sodium produced in one of these amalgams with the mercury which is agitated, and which decomposes in the second, forming caustic soda and hydrogen.

*Electrolyzer.*—The Outhenin-Shalandre electrolyzer is described and illustrated in "La Lum. Elec.," Dec. 2.

*Polarization of Platinum.*—"La Lum. Elec.," Dec. 2, reprints in abstract from "Comptes Rendus," Oct. 2, an article by Mr. Colin on the influence of the state of the surface of a platinum electrode on its initial capacity of polarization.

MISCELLANEOUS.

*Electric Furnace.*—The latest form of the Moisan furnace, mentioned in the Digest last week, is illustrated in "La Lum. Elec.," Dec. 2, taken from "Comptes Rendus," vol. 117, page 679. It is claimed that the action is like that in a reverberatory furnace, in which respect it differs from the furnaces of Siemens, Cowles and Atchenson; the substances are not in contact with the arc, and therefore are not affected by the carbon vapor which would modify the reactions; the arc is produced above a tube of carbon placed perpendicularly to the vertical plane through the two electrodes; for a continuous action this tube is inclined, allowing the molten material to run off; magnesia not being reducible by carbon does not volatilize as chalk does, the latter forming a liquid compound of calcium and carbon; when thus made it can be run for several hours with currents varying from 300 amperes at 70 volts and 1,000 amperes at 60 volts; with a tube inclined at 30 degrees and with 600 amperes at 60 volts he obtained an ingot of chromium, weighing 4.4 pounds, in ont hour.

*Electric Carriage.*—In "La Nature," Dec. 2, Mr. Hospitalier gives an illustrated description of the Pouchian carriage; the illustrations include a diagram showing the internal mechanism; the accumulators consist of six boxes of nine cells each, each cell containing one positive and two negative plates; the switch connects the cells in four different groups for as many different velocities; the motor has a power of 2 kw., which in case of need can be doubled; the total weight of the carriage without passengers is about 3,000 pounds; it will carry six passengers and will run about 42 miles over a medium pavement at a velocity of 9.6 miles per hour with one charge.

*Influence Machine for Medical Purposes.*—In an article in a French medical journal, Mr. Truchot discusses these machines, stating that the types known as the Carre, Voss and Wimshurst are better adapted to electro-therapeutics than the types known as the Holtz, Toepler and Varley.

## A Comparison of Different Systems of Electric Lighting.—II.

BY OTTO FRICK.

In order to get an idea of the cost of production for different classes of consumers, the construction, cost and expenses for rent, depreciation and repairs were divided in proportion to the demand during the hour of maximum load, assumed to be between 5 and 6 o'clock in the evening during the days before Christmas. In the same manner the expenses for coal, oil and attendance were divided according to the total annual output, this being assumed at 1,000 hours per annum for every hectowatt in use during the hour of maximum load for private lighting.

There are 3,800 hours for street lamps burning the whole night; 2,100 hours for street lamps burning until midnight, and 4,000 hours for motors and 5,800 hours for street railways. In addition current must be furnished for the city water pump, amounting to 7,460,000 hectowatt hours a year, which would only be charged with coal and oil expense as they are not in operation during the maximum load hour and therefore do not increase the capital outlay.

In Table I. will be found a summary of the construction cost arranged under the heads of generating plant, distributing plant for light and motors and distributing plant for street railway. Very much more important than the first cost is, of course, the annual expense given in Table II.

The working expenses consist of:

I. Interest on capital invested at 4 per cent. per annum.

II. Depreciation and repairs, assumed at 2 per cent. on buildings, 4 per cent. on cables and overhead lines, 6 per cent. on transformers, 8 per cent. on turbines, and 10 per cent. on boilers, engines, dynamos, switchboard, rotary transformers, accumulators, house connections and meters.

III. Management.

IV. Attendance, deduced from the different requirements for different seasons.

V. Coal and oil. Having plotted curves representing the average day load during winter, summer and spring-autumn the losses in every hour were determined between the lamps and the generating station switchboard. From the whole energy to be delivered the part that could be supplied by water power was subtracted, and the number of engines necessary for the remainder was determined, as well as the losses in the dynamos and engines. In this manner the annual indicated horse power hours as well as the annual engine and boiler hours were determined, thus enabling the amount of coal necessary for heating boilers and producing steam to be calculated for the annual h. p. hours, and also the amount of oil on the assumption that the same quantity of oil is necessary for each engine hour.

VI. Unforeseen and a reserve, with about 9 per cent. of total working expenses.

As the reproduction of the entire tables showing the losses in the different parts of the system would require too much space, only a few figures of special interest will here be given.

The Alternating Current System.—Annual efficiency of transformers, 82.3 per cent. to 83.8 per cent.; annual efficiency between lamps and switchboards, 75.7 to 74 per cent.; annual efficiency of engines and boilers, 67.8 to 74 per cent.; annual efficiency of whole plant, 51.3 to 54.7 per cent.

Direct Current System.—Annual efficiency of accumulators in per cent. of whole production of rotary transformers, 88.5 per cent.; annual efficiency between lamps and switchboards, 67.6 to 62.3 per cent.; annual efficiency of engines and dynamos, 75.5 per cent.; annual efficiency of whole plant, 51 to 47 per cent.

The first figures in each case relate to the first installation; the second to the final plant. The reason why the efficiency of the alternating system increases while that of the direct current system decreases with the extension of the plant, is to be found in the greater flexibility of the steam plant with the former, the engines in the first installation being forced to run with one-half load or less during long periods, while in the case of a direct current it runs hours at full load; but as the cables from the central station and the sub-stations are calculated for the final output they only work with the first installation at part of their full load efficiency, which is thus raised from 90 to 97 per cent.

The average cost of production in hectowatt hours and the proposed rate of charge derived from them are shown in Table III. It will be seen that the normal street railway 15 per cent. less than they will be when the whole plant is fully utilized, thus leaving a large charges have been so chosen as to fix the income from lighting and motors at about 25 per cent, and from the a direct current system is more than counterbalanced by the greater cost of rotary transformers and storage batteries, which amount to $240,000 more than the cost of the transformers.

Equally unfavorable to the D. C. system is the cost of cables. Although the high pressure cables connecting the steam power stations with the sub-stations

TABLE I.—COST OF ERECTION IN DOLLARS.

| | First installation with one water-power. | | Complete plant. with A. one water-power. | | Complete plant. with B. two water-powers. | |
|---|---|---|---|---|---|---|
| | I. Altern'ting current. | II. Direct current. | I. Altern'ting current. | II. Direct current. | I. Alternati'g current. | II. Direct current. |
| A. Generating plant. | | | | | | |
| I. Land for Water-power station | 54,800 | 54,800 | 54,800 | 54,800 | 66,700 | 66,700 |
| I. Land for Steam " " | 8,600 | 7,100 | 8,600 | 7,100 | 8,600 | 7,100 |
| II. Buildings Water-power station | 56,900 | 56,900 | 56,900 | 56,900 | 148,000 | 148,000 |
| II. Buildings Steam " " | 50,300 | 36,000 | 88,700 | 60,600 | 88,100 | 61,900 |
| III. Machinery Turbines and accessories | 14,800 | 14,800 | 14,800 | 14,800 | 29,600 | 29,600 |
| III. Machinery Boilers, feed-pumps, piping, etc | 25,900 | 18,900 | 72,800 | 46,800 | 72,800 | 46,800 |
| III. Machinery Engines, dynamos and switchboards | 77,300 | 52,300 | 244,500 | 126,100 | 246,000 | 134,200 |
| IV. Transformers | 9,500 | 9,500 | 9,500 | 9,500 | 19,000 | 19,000 |
| V. Aerial line | 16,700 | 16,700 | 16,700 | 16,700 | 27,200 | 27,200 |
| VI. Lighting of power stations, laboratory, reserve, unforeseen and superintendence | 11,800 | 12,100 | 22,900 | 19,800 | 25,900 | 22,600 |
| | 326,600 | 279,100 | 590,200 | 413,100 | 731,300 | 562,500 |
| B. Distributing plant for light and motors. | | | | | | |
| I. Land | | 7,900 | | 11,700 | | 11,700 |
| II. Buildings and street work | 43,000 | 54,000 | 105,800 | 124,200 | 105,800 | 124,200 |
| III. Transformers | 14,000 | | 50,000 | | 50,000 | |
| Accumulators, rotary transformers and switchboards | | 73,700 | | 290,000 | | 290,000 |
| IV. Cables | 141,600 | 174,200 | 332,000 | 392,200 | 332,000 | 392,200 |
| V. House connections and meters | 32,200 | 32,200 | 119,000 | 119,000 | 119,000 | 119,000 |
| VI. Reserve, unforeseen and superintendence | 9,600 | 13,400 | 21,300 | 32,700 | 21,300 | 32,700 |
| | 240,400 | 355,400 | 628,100 | 969,800 | 628,100 | 969,800 |
| C. Distributing plant for street railway. | | | | | | |
| I. Buildings and street work | 5,000 | 5,000 | 5,600 | 5,600 | 5,600 | 5,600 |
| II. Rotary transformers and switchboard | 10,200 | 10,200 | 22,400 | 22,400 | 22,400 | 22,400 |
| III. Cables | 24,300 | 24,300 | 36,300 | 36,300 | 36,300 | 36,300 |
| IV. Reserve, unforeseen and superintendence | 5,500 | 5,500 | 8,100 | 8,100 | 8,100 | 8,100 |
| | 45,000 | 45,000 | 72,400 | 72,400 | 72,400 | 72,400 |
| Total costs of construction | 612,000 | 679,500 | 1,290,700 | 1,455,300 | 1,432,100 | 1,604,700 |
| Cost per hectowatt delivered to consumers in the hour of max. load | 88.5 | 98.3 | 50.5 | 56.8 | 56 | 62.7 |

TABLE II.—ANNUAL WORKING EXPENSES IN DOLLARS.

| | First installation one water-power. | | Complete plant. A. one water-power. | | Complete plant. Two water-power. | |
|---|---|---|---|---|---|---|
| | Alt. cur. | Dir. cur. | Alt. cur. | Dir. cur. | Alt. cur. | Dir. cur. |
| | Private lighting. | | | | | |
| I. Share of capital-in'erest, depreciation and repairs | 33,250 | 36,850 | 79,700 | 93,000 | 85,900 | 99,200 |
| II. Share of managem'nt | 4,100 | 3,220 | 5,930 | 5,290 | 5,930 | 5,290 |
| III. " " attendance | 3,070 | 3,380 | 6,680 | 7,690 | 6,420 | 7,370 |
| IV. " " coal and oil | 3,200 | 2,780 | 20,120 | 24,000 | 13,410 | 16,420 |
| V. " " unforeseen and reserved | 5,120 | 4,160 | 14,050 | 12,920 | 12,880 | 12,490 |
| Total annual working expenses | $ 48,740 | $ 50,390 | $ 126,480 | $ 142,600 | $ 124,540 | $ 140,740 |
| Cost of one hectowatt-hour delivered to consumer | ¢ 1.08 | ¢ 1.117 | ¢ 0.743 | ¢ 9.837 | ¢ 0.732 | ¢ 0.823 |
| | Public lighting. | | | | | |
| I. Share of capital-in'erest, depreciation and repairs | | | 10,800 | 12,930 | 11,670 | 13,800 |
| II. Share of managem'nt | | | 810 | 740 | 810 | 740 |
| III. " " attendance | | | 910 | 1,060 | 870 | 1,020 |
| IV. " " coal and oil | | | 8,120 | 9,630 | 5,420 | 6,610 |
| V. " " unforeseen and reserved | | | 1,910 | 1,760 | 1,750 | 1,730 |
| Total annual working expenses | | | $ 22,550 | $ 26,120 | $ 20,520 | $ 23,900 |
| Cost of one hectowatt-hour delivered to consumer | | | ¢ 0.331 | ¢ 0.383 | ¢ 0.301 | ¢ 0.350 |
| | Motors. | | | | | |
| I. Share of capital-in'erest, depreciation and repairs | 9,260 | 10,250 | 19,900 | 23,610 | 21,500 | 25,230 |
| II. Share of managem'nt | 1,140 | 890 | 1,490 | 1,350 | 1,490 | 1,360 |
| III. " " attendance | 840 | 940 | 1,670 | 1,920 | 1,610 | 1,870 |
| IV. " " coal and oil | 3,560 | 3,260 | 20,100 | 24,000 | 13,400 | 16,430 |
| V. " " unforeseen and reserved | 1,420 | 1,160 | 3,510 | 3,230 | 3,230 | 3,180 |
| Total annual working expenses | $ 16,220 | $ 16,500 | $ 46,670 | $ 54,120 | $ 41,230 | $ 48,060 |
| Cost of one hectowatt-hour delivered to consumer | ¢ 0.322 | ¢ 0.329 | ¢ 0.274 | ¢ 0.317 | ¢ 0.242 | ¢ 0.282 |
| | Street railway. | | | | | |
| I. Share of capital interest, depreciation and repairs | 10,000 | 12,730 | 13,100 | 14,420 | 14,070 | 16,560 |
| II. Share of managem'nt | 1,730 | 2,560 | 950 | 1,800 | 950 | 1,800 |
| III. " " attendance | 1,620 | 2,350 | 1,640 | 2,470 | 1,600 | 2,380 |
| IV. " " coal and oil | 5,820 | 4,730 | 16,930 | 16,760 | 11,270 | 11,500 |
| V. " " unforeseen and reserved | 1,790 | 3,310 | 2,260 | 4,310 | 2,050 | 4,240 |
| Total annual working expenses | $ 20,660 | $ 25,680 | $ 34,880 | $ 39,760 | $ 29,940 | $ 36,480 |
| Cost of one hectowatt-hour delivered to consumer | ¢ 0.243 | ¢ 0.302 | ¢ 0.235 | ¢ 0.256 | ¢ 0.193 | ¢ 0.236 |
| | City water pumps. | | | | | |
| I. Share of capital interest, depreciation and repairs | | | | | | |
| II. Share of managem'nt | | | | | | |
| III. " " attendance | | | | | | |
| IV. " " coal and oil | 4,430 | 3,370 | 6,190 | 6,320 | 4,400 | 4,270 |
| V. " " unforeseen and reserved | | | | | | |
| Total annual working expenses | $ 4,430 | $ 3,370 | $ 6,190 | $ 6,320 | $ 4,400 | $ 4,270 |
| Cost of one hectowatt-hour delivered to consumer | ¢ 0.59 | ¢ 0.045 | ¢ 0.083 | ¢ 0.085 | ¢ 0.059 | ¢ 0.057 |

margin. The results founded on these charges, reduced by 25 per cent. and 15 per cent. respectively, as above stated, are shown in Table IV., which also contains the comparative results from the different dispositions and the total dividends on the invested capital that will certainly be obtained.

This table shows that in all cases the alternating cur-

TABLE III.

| | Production cost per hectowatt hour. | | Tariff per hectowatt hour. | |
|---|---|---|---|---|
| | First installation. | Complete plant. | First installation. | Complete plant. |
| Private lighting | 1.1 | 0.74 | (7.5) 1.79 | (5.5) 1.31 |
| Public lighting | ... | 0.33 | .... (2.25) | (2) 0.48 (2) |
| Motors | 0.32 | 0.27 | 0.54 (1.5) | 0.48 (1 5) |
| Street railway | 0.24 | 0.23 | 0.36 (0.35) | 0.36 (0.35) |
| City water pumps | 0.06 | 0.06 | 0.083 | 0.083 |

rent system gives a better return on the invested capital. On investigation of Table II. it will be found that the difference in expense is almost exclusively caused by the greater capital outlay with the direct current system, and in other instances a comparison between the two systems has been similarly unfavorable to the direct current for the same reason. This greater capital investment also involves a larger amount for depreciation. Taking Table I. we find that the difference of $317,300 minus $172,900, or $144,000, on the cost of the generating steam plant in favor of are smaller and cheaper by $38,000 than in the A. C. system, the cost of the low pressure feeders exceeds the cost of the primary high pressure network by $100,000, thus leaving a balance of $62,000 in favor of

TABLE IV.

| | First installation. | Complete plant. | | | |
|---|---|---|---|---|---|
| | With one water-power. | With one water-power. | | With two water-powers. | |
| | Altern. current. | Direct current. | Altern. current. | Direct current. | Altern. current. | Direct current. |
| Total income | $114,900 | $114,900 | $320,500 | $320,500 | $320,500 | $320,500 |
| Total expenses | 90,050 | 95,940 | 236,770 | 268,920 | 220,630 | 253,450 |
| Gain | 24,850 | 18,960 | 83,730 | 51,580 | 99,870 | 67,050 |
| Total interest (inc. 4% on capital) in %. | 8.1 | 6.8 | 10.5 | 7.5 | 11 | 8.2 |

the A. C. system. The total difference under those two heads amounts thus to $62,000 plus $99,500 or $157,500, which sum will be found to be very nearly equal to the total cost given in Table I., and requires an annual charge for depreciation of $12,000 and of $6,300 for interest, or in all $18,300, which very nearly corresponds with the difference in total costs as given in Table IV. From these figures we may conclude that to render it possible for the D. C. system to compete with the A. C. system in a case like the present, it is necessary to reduce the initial outlay through improvements in storage batteries, rotary transformers, and heavy cables as used for low pressure feeders.

The way in which the selling prices have been arrived at is of the more interest as they permit us to get a very exact idea in regard to the prices at which electrical energy can be sold to different kinds of customers. It shows very evidently that the electric motor can successfully compete with gas engines, and smaller steam engines, taking in account the much less expense for repairs, oil and attendance which its use involves. Street lighting can also be made very low, and even incandescent lighting will stand comparison with gas.

The principles underlying the work of which the most interesting results have been exposed here should receive general approval, affording, as it does, the only way by means of which a true judgment regarding the value of different systems can be obtained.

## A Telegraph Storage Battery Plant.

BY R. MACRAE.

Although storage batteries have been in use for some time in telegraph stations abroad, until recently no steps have been taken in this country to adopt them for this class of work.

A description of the storage battery plant recently installed in the office of the Postal Telegraph Company, at Baltimore, will be of interest to those who are using primary cells for similar work. This is the first telegraph office in the United States to adopt this system, and it is now using storage batteries exclusively for the transaction of its business. Before commencing to make the installation some preliminary tests were made in order to form an estimate of the size and number of storage battery cells that would most economically replace 2,500 large gravity cells formerly used, and also to determine the most suitable method for charging the battery. As one end of a battery used on telegraph lines must be connected to the earth, it was found impracticable to charge the batteries directly from the street mains and at the same time use the batteries for telegraph work.

To obviate the necessity of changing the circuits and using extra sets of batteries, a motor-generator was adopted for supplying current to the battery. In this way the street mains are entirely insulated from the charging circuit, and the battery can be recharged and used at the same time. The loss in the transformer is inappreciable.

Although the voltage of one storage cell is only equivalent to that of two Daniel cells, it was found that on account of the low internal resistance of the storage cells a number of circuits could be operated from the same battery, and that where the working conditions are similar to those in this office, one storage cell will replace five or more primary cells of the type now generally used. The fall of potential at the terminals of a primary battery when the circuit is closed renders it impracticable to work more than one or two circuits from the same battery. With storage batteries, on the other hand, the number of circuits that can be operated in parallel is limited only by the maximum discharge rate advisable for the size of the cells employed.

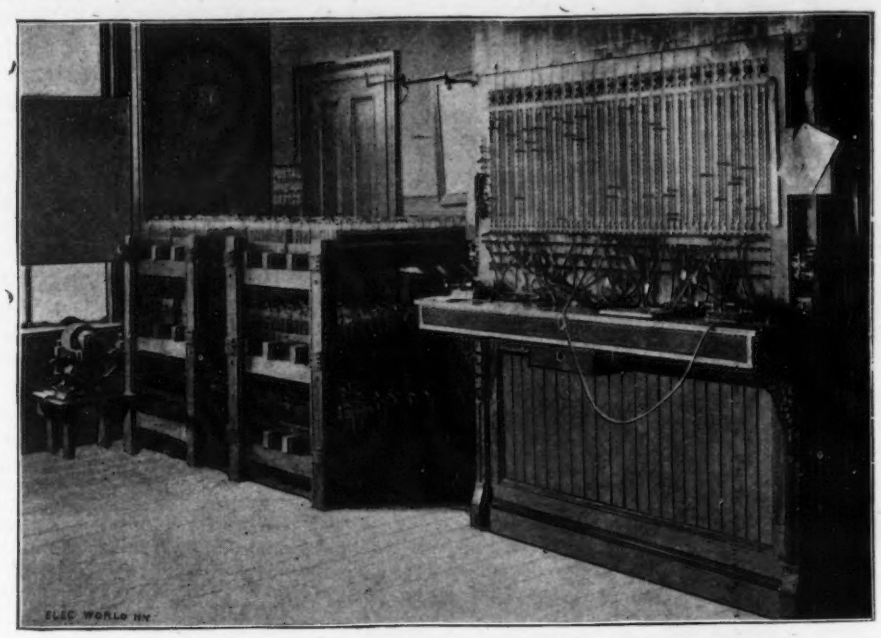
With the above result as a basis, a plant of 500 storage cells of the type "3A" Donaldson-Macrae battery, with a ½ h. p. motor-generator of the same make, was installed a short time ago, and is now found to be amply sufficient to do the work previously done by about five times that number of primary cells. In a larger station operating more circuits it would be necessary only to increase the charging facilities without increasing the number of cells, as all circuits requiring nearly the same voltage can be connected to the same battery.

The battery is placed on two stands as shown in Fig. 1, each stand being capable of holding 300 cells and measuring 4 feet long, 3 feet wide and 4½ feet high. For convenience in handling, the cells are arranged in groups or trays as shown in Fig. 2, each tray containing ten cells. The element itself consists of one positive plate or section placed in a frame made of two half sections, which constitute the negative plate, as shown in Fig. 3. The insulating rubber rods are attached to the negative element in such a manner as to render short circuiting impossible, and also to facilitate the insertion of a new positive element when renewals are necessary. Each element complete weighs 3½ pounds, and has a capacity of 30 ampere hours. The glass containing jar measures 3 by 4 by 5 inches. The motor-generator is shown in Fig. 1; it is operated from a 110-volt circuit, and takes from 3 to 4 amperes, and gives a charging current of from 2 to 3 amperes. Connected with the generator are fuse blocks and polarized trip-switches to prevent the battery current from passing into the motor-generator in case of an interruption to the motor current.

The battery is divided into twelve groups or sections, one section being charged at a time. In each group of cells is placed a small hydrometer to indicate the state of charge of that section. Every morning the specific gravity, indicated by these hydrometers, is observed, and the charging current is switched onto the battery which

shows the greatest exhaustion. In this way the entire battery is always kept well charged. It is found that it is not necessary to keep the generator running at its full capacity to keep the cells in good condition. In fact the demand on the cells is such that the charging current might be interrupted for several days without interfering in any way with the battery service.

The advantage of using a storage system for this class of work has long been recognized. A Daniel cell in constant operation on a quadruplex circuit gives an average current of about 0.1 ampere, or 875 watt hours per annum, and costs to maintain, at the very lowest estimate, $1.10. The same number of watt



F.G. 1.—STORAGE BATTERY TELEGRAPH PLANT.

hours, if furnished by the electric light companies of Baltimore, would cost nine cents.

That lead batteries have not been adopted for this work before now has not been due to a lack of efficiency in these batteries as reservoirs of electricity, but to the fact that the earlier forms of lead batteries could not be depended upon to furnish the interrupted service demanded in telegraph work. A cell was liable at any time to become short circuited; often by a particle of active material, so small as to escape observation. A cell partially short circuited in this way would not only cease to contribute useful effect, but would introduce a counter electromotive force more than sufficient to neutralize that of a good cell, thus diminishing the E. M. F. of the battery to the extent of about five volts.

No amount of attention or care on the part of the person in charge of the battery could prevent these accidents, which were attributed not to faulty construction, but to inherent defects inseparable from lead batteries. The long time that it has taken to overcome these defects has strengthened this opinion. Such sources of annoyance no longer exist in cells that are properly made, and a lead battery can now be relied upon to do a certain amount of work with as much

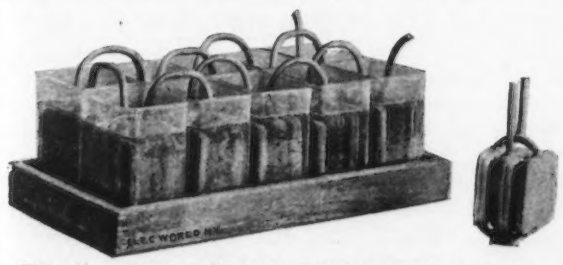


FIG. 2.—CELLS USED IN TELEGRAPH PLANT.

confidence as can be placed in any primary battery. It is not here claimed, however, that a lead battery requires absolutely no attention or that the plates harden wth age and last indefinitely. The negauve plates, it is true, if properly made and protected from mechanical injury, show no signs of deterioration after years of constant service, but the positive have to be renewed every two or three years, depending upon the character of the work performed. The positives can, of course, be made to last longer by making the metallic support heavier, but for ordinary work nothing is gained by making the plates too heavy. Unlike the zincs in a primary battery, there is no destruction of the material in a lead positive, and it can be reconstructed at a small cost.

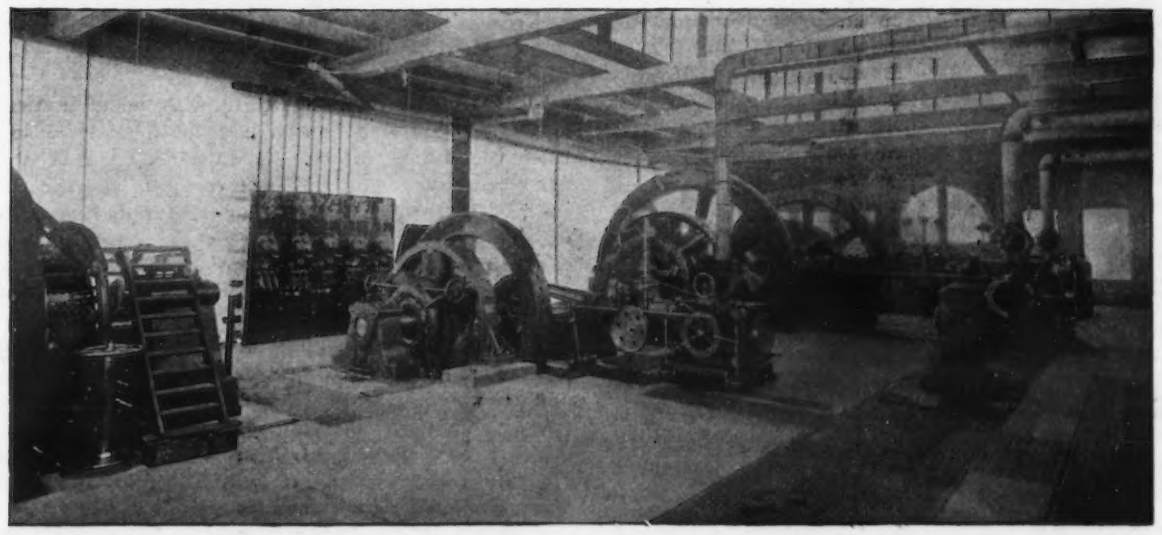
Replacing the positives is as simple an operation as renewing the zincs in a primary battery, and should be attended to before the plates are so far impaired as to interfere with the battery service. A gradual diminution of the electric capacity of the battery will indicate when new positives are needed.

In setting forth the claims of a lead battery it has not been usual to give too much prominence to the question of renewals. So much has been said about the ideal storage system that a general impression exists that a storage battery with any claims to recognition should require even less attention than a water tank. If the depreciation factor is not reduced to zero, it is considered equal to an admission that the battery is still in an experimental stage, and unfit for practical application. It is safe to say that the storage battery of the future has contributed more than any other cause to retard the development of the storage battery of the present.

### A St. Louis Electric Railway.

The Cass Avenue & Fair Grounds Railway has installed a model power station for its electric lines, which now comprise 35 miles, over which are operated 70 cars, built in the car shops of the St. Louis Car Company.

The power house is a substantial brick structure, with a frontage of 168 feet, and a depth of 164 feet. The engine room measures 164 by 58 feet, and the boiler room 164 by 50 feet. Between them is a roadway 8 feet wide, which runs the entire depth of the building. The room above this is used for storage purposes. In the boiler room, which is 20 feet below level, set in pairs are six down draft return tubular boilers, from the works of the O'Brien Boiler Works, at St. Louis. These are 22 feet by 5 feet 6 inches, and have 18 6-inch diameter flues, conducting to three sheet steel chimneys, each 100 feet high. A conveyor running along the floor in front of the furnaces, and operated by a small upright engine,



A MODEL RAILWAY PLANT.

carries away the ashes and loads them on wagons. Two No. 7 Hooker pumps are comprised in the equipment, and the water is heated in a feed water heater of the Excelsior type.

The engine plant consists of four Reynolds-Corliss horizontal engines from the shops of the E. P. Allis Company, of Milwaukee. Three are 1,000 h. p. each, with cylinders 34 by 60 inches, and the fourth of 350 h. p., with cylinders 18 by 36 inches. The flywheels of the large engines weigh 65 tons each, and revolve at 92 revolutions per minute; the speed of revolution of the smaller engine is 150. The large engines have been worked up to 1,500 h. p., or half as much again as their indicated capacity. They take care of the day service, while the small combination is used to run the all-night cars.

The most striking feature of the station is, that it is entirely direct connected, the belt driven machine having no place there. It resembles the model railway plant shown in the Intramural power house, at the Columbian Exposition. Three General Electric Company's 750 kw. ten-pole, 100 revolution generators are directly connected to the three large engines, and one 200 kw. six-pole 100 revolution generator to the smaller. The generators are of the latest railway type, and like their prototypes at the World's Fair, have already come up to and even exceed specified requirements. The switchboard is equipped entirely with General Electric Company apparatus of the usual type, and is also provided with automatic circuit breakers with electrical reset.

The overhead and line appliances are exclusively from the General Electric shops. The track is built in a substantial manner, and laid with a Johnson 85-pound girder rail, with supported joints, the ties being laid 12 to the rail. Johnson tie plates are also used, but no chairs. The curve rails are 100 pounds, and the poles were made by the Walworth Manufacturing Company.

Each of the 70 cars are equipped with General Electric motors, and type E and K controllers, and their operation has not only given satisfaction but also elicited high praise. Of the operation of the road as a whole, Mr. McCulloch, vice-president and general manager, has to say:

"We have not had an instant of delay, and only such trifling troubles as are incident to the handling of new machinery by inexperienced men. I attribute our successful start in electric life to the excellence of the electrical apparatus and devices you have given us. We have operated thus far with absolute freedom from electrical annoyances, and if our plant were to be duplicated I see no reason why we should make the slightest change from the present one."

### The Official Vocabulary for Code Telegrams.

This vocabulary, says the London "Electrician," is now being prepared by the International Bureau of Telegraphic Administrations, at Berne, in accordance with the decision of the International Telegraphic Conference, of Paris, 1890. It will contain about 240,000 words, selected from the eight authorized languages—English, French, German, Spanish, Italian, Dutch, Portuguese and Latin. Inflections of words, declension, conjugation, comparative and superlative, will be used, as well as a certain number of proper names. The words will contain at least five and at most ten letters, and will form a single series, alphabetically arranged, and numbered from 000000 to 240,000, the different languages being mingled according to alphabetical order. The words are not to present any distinction showing the language to which they belong, and each page will measure 11.8 inches by 7.87 inches, containing 300 words. The vocabulary is to be printed in clear characters on paper of good quality. Editions containing part of the words, or the words of a single language, will not be published. Three years after publication the use of this official vocabulary will become obligatory for the European Telegraphic Service, and later on, doubtless, for extra-European messages. The vocabulary is the property of the administrations forming the Telegraphic Union, who will bear in the first instance the cost of compilation and printing. It is announced that the official vocabulary will be published some time in 1894.

### Triple Expansion Engines in Electric Lighting Stations.

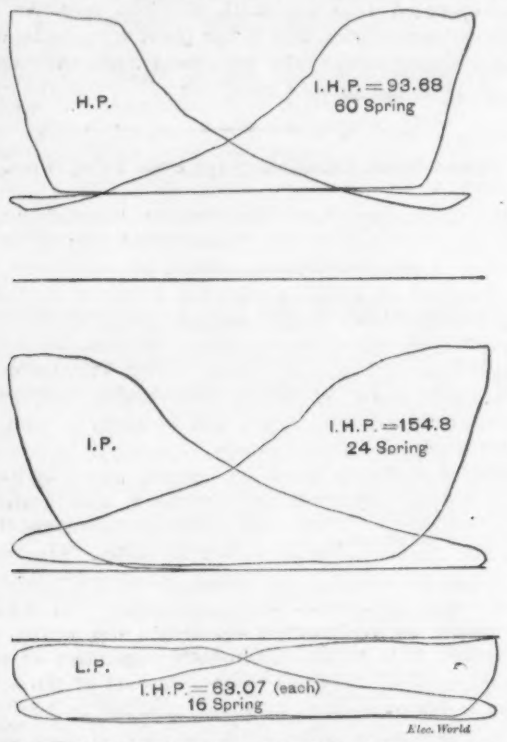
Of the many problems of interest to central station managers one of the most important is that with regard to how far one can go in the direction of multi-cylinder engines, and by so doing effect a saving in fuel commensurate with the greater cost of installing this class of engines?

An increase in the number of cylinders narrows the limits of economical working, and the more variable the load the less is the saving which can be effected by their use. The question is, when do they pay? In the largest cities, in stations for incandescent lighting, it has been found that triple expansion engines are perfectly feasible and effect a large saving. This work, of course, is of a very favorable nature, enabling the units to be always kept well loaded. In smaller cities, however, and where the work is of a varied kind, such as arc, incandescent, or motor work—generally a combination of the three—there has not been much done in this line, and it has been considered by most engineers that the efficacy of using triple expansion engines as a means of saving coal is somewhat

problematical on account of the variable load generally found in such stations; while all concede that if this class of engines should prove to be coal savers to a considerable extent, their use is greatly to be desired, and will help toward placing many stations of this kind upon a good paying basis.

We are glad to present to our readers in this issue a reproduction of some indicator cards taken from a triple expansion engine in such a situation which show splendid results in the line of fuel economy. The station in question is that of the Elmira Illuminating Company, Elmira, N. Y., and which is entirely the design of the efficient general manager, Mr. F. A. Cheney. The engine was built by McIntosh, Seymour & Co., of Auburn, N. Y., and is of the vertical four-cylinder triple expansion type, of a nominal capacity of 500 horse power.

In this station the day load consists of motor and electric railroad circuits only, which are run from separate horizontal compound engines. The 500 h. p. triple expansion engine is started when the lighting comes on, and runs until midnight. From midnight until morning a smaller horizontal triple expansion engine carries the lighter load, which is pretty nearly constant, consisting largely of arc lights. These cards, taken from the large engine, show the minimum and maximum loads under which it runs, the light cards giving the Sunday evening load when lightest, and the heavy cards being taken slightly before six o'clock, when both store and house lights are on, and the load is heaviest. It can readily be seen that in both of those extreme cases the engine is working under favorable conditions as regards economy of fuel. The lateness of the cut-offs which occur in triple expansion engines imposes a very difficult duty on the governor of the engine, much more so than is mommon in single cylinder and compound engines, by reason of the greater range through which it has to act. Upon this engine, at full cut-off, which is at 0.8, the speed only falls off three turns (abou. 2 per cent) from that when the engine is running with no load, and condensing, which is certainly a very remarkable result. It will be noted that by having the cut-off valves operated by the governor, the receiver pressures and the drop of temperature in the cylinders are kept practically constant, and the economy of the engine is always the best obtainable for the conditions under which it is running without any adjustment of the valves being required.




TRIPLE EXPANSION INDICATOR CARDS.

As to practical results, comparing the percentage of the coal bill to gross receipts of the company from business shows a saving in fuel of 61 per cent, as compared with results obtained in the old station, comparison being made between the results obtained during the months of November this year and last, which should give as fair a test as is possible.

As to the question of desirability of vertical engines, at least as far as this particular engine is concerned, it is significant that the only fault the owners have to find with it is that it runs so smoothly and is so easy to care for that the engineers have an inclination to run it during the hours of light load instead of the smaller engine provided for that purpose.

## A New Sight Feed Oil Cup.

The accompanying engraving illustrates a new oil cup for dynamo, motor and engine bearings, made by the Lunkenheimer Company, Cincinnati, and known by the name of the Crown Index sight-feed glass oil cup. The cup is provided with an index device for regulating the flow of oil and an indicator arm which turns on the lid to mark the notch giving the desired feed. When desired the feed can be instantly turned off, and on again, by replacing the index lever in the notch of the indicator arm. When the index arm is closed, the lever can be left standing up, thus acting as an indicator to show from a distance that the feed is shut off. When an extra amount of oil is wanted, it can easily be supplied with the Crown cup without losing the original feed, by simply moving the indicator arm a few notches to the right, and, when the normal feed is again required, it is then only necessary to replace the arm in the index slide which marks that feed. The cups are all made of

SIGHT FEED OIL CUP.

cast brass, handsomely finished, and are heavy and durable. The oil, it is claimed, will not leak out between the brass and the glass parts as is the case with all ordinary spun brass cups.

## Some "Theories."

That "theory" is in disrepute with many naturally follows from the conception most of these have as to what constitutes theory. As an illustration of what passes as theory with this class we print the following contribution, which is rather an exaggerated sample of many we receive. We trust that the writer will not misconstrue our motive in printing it with this comment, our object not being to ridicule but to point a moral:

Magnetism, it is logical to infer, is a mode of motion, differing from electrical motion in the longer length and lesser frequency of waves both in dense matter and ether. Doubtless the magnetic waves differ in frequencies to a limited extent as in heat and light, etc. Magnetic waves are subject to the same laws of radiant waves as are the other energies.

The cause of the gradual growth in the strength of a magnet when the armature is on, the inverse being true when armature is off, is the rhythmic motion between the armature and the magnet, produced by the struggle between adhesion and gravitation, and magnetic attraction and gravitation are probably the cause of the growth of magnetic strength.

A Theory of Terrestrial Magnetism.—Terrestrial magnetism is probably caused by a number of effects. 1. By the enormous heat in the interior of the earth gradually cooling down the colder portions of the earth, or the poles, becoming most magnetic. 2. By the rotary motion of the earth causing torsion in magnetic metals in the earth. 3. Another possible cause is the electrified air and water flowing from the equator toward the poles. This last is an old hypothesis.

Universal Magnetism.—It is probable that there is iron in all or nearly all the worlds and meteors, and the worlds and meteors are magnets for similar reasons to those given above. The magnetism of these is slowly radiated off universally into space.

Universal Electricity.—As all the other worlds are probably heterogeneous, also doubtless nebulae, and most of the meteors and comets, all are charged with electricity. Those bodies which are not heterogeneous are doubtless electrified by radiant electricity from other bodies. Thus, it is logical to infer that the whole universe is vibrating radiant electric waves.

Diamagnetism.—Diamagnetic waves are probably of greater lengths and slower frequencies than those of magnetic waves.

## NEW BOOKS.

A Manual of Telephony. By W. H. Preece, F. R. S. and Arthur J. Stubbs. London: Whittaker & Co. 1893. 508 pages, 333 illustrations. Price $4.50.

The present volume replaces the well known work, "The Telephone," by Preece and Maier, it not having been considered advisable, in view of the rapid strides in practical telephony made in the past five years, to merely revise that work for a new edition.

The book is divided into six parts, of which Part I., of five chapters, deals with transmitters and receivers theoretically, historically and practically. The three chapters of Part II. are devoted respectively to complementary devices used with telephones, such as bells, relays, etc., to descriptions of some typical forms of complete instruments and to a discussion of plans for dealing with intermediate stations. Part III., three chapters, contains information respecting simple exchanges, while the five chapters of Part IV. deal entirely with the important subject of switchboards. Seven chapters in Part V. are on subjects having a close association with exchange matters, together with some having a more general bearing, such as domestic switchboards and military and selective signaling. The last section, Part VI., of five chapters, deals with line construction, aerial, subterranean and submarine. The illustrations have apparently been drawn with care, and those of instruments are plan views in order to give a more correct idea of construction. The diagrams which show the systems of connections have been made on a uniform plan, so that differences between various systems may be more readily traced.

As may be judged from the above résumé, the work is what it purports to be, a manual on the art of telephony, and as such will be found of the greatest value to all those connected with that branch of electricity. Owing to the experience and opportunities of the authors, one of whom is the engineer-in-chief and electrician of the English telephone system, and the other connected with its technical office, the information in the work has the weight of high and competent authority, and is beyond question the best treatise on the subject.

The Incandescent Lamp and Its Manufacture. By Gilbert S. Ram, A. I. E. E. London: "The Electrician" Printing and Publishing Company, 1893. 218 pages; 69 illustrations. Price $3.00.

With the exception of a few minor treatises the incandescent lamp has received little attention outside of periodical literature, notwithstanding the natural interest attached to the subject. This, as remarked by the author, has been due to the monopoly in the lamp industry, which has had the effect of repelling study and experiment, while the various processes of manufacture have been guarded as factory secrets. As a thorough understanding of the lamp and the possibilities of its improvement can only be obtained by considering the various processes of its manufacture, the author thinks it probable that a work on the subject at the present time will be welcomed by those interested therein, in which the reader will doubtless concur.

The first eight chapters are devoted to the filament, in which its material, preparation, carbonization and hydrocarbon treatment are considered. The preparation of cotton and process filaments is referred to at greater or less length, but silk and bamboo filaments are dismissed with a few words. The processes of carbonization and mounting are described and the flashing process treated at considerable length. Two interesting chapters contain a discussion of the principles for the predetermination of the dimensions of filaments for any voltage and candle power, illustrated by curves.

Four succeeding chapters are on measuring filaments, glassmaking, glassblowing and sealing-in respectively, followed by a lengthy chapter on the vacuum, which describes various pumps, processes and methods of testing the vacuum, and goes into considerable detail as to the practical operations of exhausting.

Testing and capping are next treated, and the two final chapters are on efficiency, duration and the relation between light and power. These latter chapters are the most unsatisfactory in the book. They not only contain nothing new, but do not refer to the extensive work done in America in this direction, where, indeed, the questions relating to these subjects have alone received adequate recognition. While the book is therefore deficient in the treatment of the principles relating to the various economic questions connected with the incandescent lamp, and does not even refer to gas and separable lamps, it will be found extremely useful otherwise.

Galloupe's General Index to Engineering Periodicals, from 1888 to 1892, Inclusive. By Francis E. Galloupe, M. E. Boston: 55 Kilby street. 396 pages; price, $3.

This is the second volume of this work, and covers the period from 1888 to 1892, inclusive. The purpose of the work is to render accessible to engineers in all branches of the profession, as well as to special investigators, librarians, editors and others, the more important papers and articles published in the leading American and English journals. That such an index is sadly needed there can be no doubt. A vast amount of most valuable matter is buried in the periodical literature of the day, and every means to reach this material is especially welcome. This work bears evidence of care-

ful and conscientious labor, and a large portion of the field has been covered. The criticism that can invariably be passed upon this kind of works—that they are incomplete—holds true in this case. As is usually the case with an index designed to cover all branches of engineering, that portion dealing with electrical subjects lacks the careful classification essential to such a reference. It is to be regretted that such a valuable source of information, for example, as the "Proceedings of the American Institute of Electrical Engineers," is not indexed, and that of the English electrical journals, only one, the London "Electrical Review," is referred to. It would also seem that the index would be somewhat more systematic and accessible if the admirable standard established by the American Library Association was followed a little more closely.

# Financial Intelligence.

## THE ELECTRICAL STOCK MARKET.

NEW YORK, Dec 22. 1893.

THE ELECTRICAL STOCK MARKET has somewhat fallen into the background as a sptculative factor, owing to other financial transactions, which have diverted the usual interest in them. Unlisted securities have done a little better than the listed, and at present their prospects look fully as promising.

GENERAL ELECTRIC STOCK has had an off week again and lost nearly all the points the stock gained a week ago. Therewas a general bear raid early in the week, which carried down the leading industrials General Electric with it. The stock did not recover from the effects of this, and closed 2¼ points below quotation of the last week. The happenings of the week have not been conducive to give any stock a rise. The failure of the St. Nicholas Bank, the probable receivership of the Atchison, Topeka & Santa Fe Railroad, and the general dulness has had a depreciating effect upon the market, so that a rise could not be expected of any stock unless some special features were connected with it. The features of General Electric have been the report that the Schenectady works of the company would start on full time Jan. 1, and that the company will abandon its factories at Lynn and Orange, and concentrate all its plant at Schenectady. This extension at this factory is probably reported as a sequel to the statement last week of a $1,500,000 contract which the company had secured. Nothing more definite of the transaction is yet known, however, and good business prospects without facts do not count essentially in stock quotations. The rumor of making the Schenectady works the only manufacturing plant of the company is looked at in Wall Street as an indication that the New York end of trust were having their own way, and that the New England shareholders are getting worsted. However, the true state of affairs is not diffused widely to the public, and rumors constitute most of the basis of the company's affairs. The officials are as ready with denials of onslaughts against the company as ever, but do not make explicit statements. Vice-President Herrick said to-day that the company would be out of debt in 60 days, but did not give the figures explaining the method of accomplishment. If the company was more open with detailed statements of business and contracts the stock might secure better prices. It is now between 36 and 37.

WESTERN UNION TELEGRAPH being an ex-dividend stock, and with the general decline of securities, has also fallen a few points. There has been a considerable trading in the stock, and no confirmation of rumors of financial troubles, which have been circulated.

WESTINGHOUSE ELECTRIC MANUFACTURING COMPANY stock has depreciated very slightly. The company's business is said to be increasing gradually, and its stock is still kept out of the speculative market, and traded in principally upon its worth as an industrial investment security.

BROOKLYN EDISON ILLUMINATING is slowly but surely working its way upward to par. Brokers dealing in it report many inquiries of it, and a few sales and limited amount in the market, which are all indications of better prices for it. The stock is now bid at 99 and offered at 102.

ELECTRICAL STOCKS, DEC. 21, 1893.

| | Par. | Bid. | Asked. |
|---|---|---|---|
| Brush Ill., New York | 50 | 20 | 40 |
| Detroit Electrical Works | 10 | 2 | 3 |
| Cleveland General Electric Co | .. | 85 | 90 |
| East River Electric Light | 100 | .. | 65 |
| Electric Con. & Supply Co. pref. | 15 | 15 | 16 |
| " " " " " com | 15 | 15 | 17½ |
| Edison Electric Ill., New York | 100 | 98 | 100 |
| " " " 1878 | ... | 101 | 100 |
| Edison Electric Ill., Brooklyn | 100 | 99 | 102 |
| " " " Boston | 100 | 115 | 120 |
| " " " Chicago | 100 | 220 | 230 |
| " " " Philadelphia | 100 | 120 | 125 |
| Edison Electric Light of Europe | .. | 2½ | 5 |
| " Bonds | .. | 80 | 85 |
| " Ore Milling | .. | 5 | 12 |
| Fort Wayne Electric | .. | 5 | 9 |
| General Electric Company | 100 | 36¾ | 37 |
| " " deb. 5's | .. | 80 | 81 |
| Interior Conduit and Ins. Co | 100 | 25 | 35 |
| Mount Morris Electric | .. | .. | 65 |
| Westinghouse Consolidated | 50 | 23½ | 24½ |
| " " pfd | 50 | 41 | 43 |
| Western Union Telegraph | .. | 84 | 85 |

## NEW INCORPORATIONS.

THE CHAMBERLAIN ELECTRIC LIGHT AND POWER COMPANY, Chamberlain, S. Dak., capital stock $200,000, has been formed for producing electric light and power. H. H. Natwick, J. L. Stene and M. E. Distad.

GLENWOOD AND DRAVOSBURG ELECTRIC STREET RAILWAY COMPANY, Pittsburgh, Pa., has been formed to construct and operate an electric railway in Allegheny County, Pa. I. J. Wilson, J. P. Wilson and H. H. Swaney are interested in this company.

THE MONTANA CONSTRUCTION COMPANY, Helena, Mont., capital stock $150,000, has been formed to contract for the construction of railways, tramways, all kinds of water rights, electric plants, etc. H. Elling, R. A. Harlow and S. Ward, are interested.

THE OAKLAND WATER COMPANY, San Francisco, Cal., capital stock $3,000,000, has been formed to supply electric light and power and water, etc. A. Hayward, A. Rose, Jr., San Mateo; W. I. Dingee, Oakland; H. G. Stevenson, Mendo Park, and W. E. Sell, Berkeley, are the promoters.

THE ROSS EFNDER COMPANY, Washington, D. C., maximum capital stock $250,000, has been formed to furnish electric, cable and other cars with safety fenders, etc. A. B. Russ, Chicago, Ill.; A. Hotchkiss, Baltimore, Md., and H. H. Blackburn, Washington, D. C., are the organizers.

THE BERKSHIRE ELECTRIC LIGHT, HEAT AND POWER COMPANY, Monterey, Mass., capital stock $10,000, has been formed to manufacture, sell and distribute electricity for various purposes. G. O. Eterich, Clayton; W. E. Hyer, Monterey, and G. A. Stevens, New Marlsboro, Mass., are the organizers.

THE WEAVER ELECTRIC COMPANY, Jackson, Miss., capital stock $20,000, has been formed to manufacture and sell all kinds of electrical and telegraph instruments. A. P. Weaver, W. Watson, W. W. Stone, W. D. Holder, A. L. Julienne, R. J. Hardin, T. M. Henry, all of Jackson, are the interested parties.

THE TIFFIN AND INTER-URBAN CONSOLIDATED RAILWAY COMPANY, Tiffin, O., capital stock $300,000, has been formed to construct and operate electric, cable, steam and other horse railways. T. B. Williams, C. F. Williams, F. W. Brightman, N. W. Miller, M. Frost, A. Betts, R. W. Brown and T. Rosendale are the promoters.

THE GENERAL MANUFACTURING COMPANY Bound Brook, N. J., capital stock $2,500,000, has been formed to manufacture, buy, sell and deal in sewing machines, electrical devices, tools, machines, etc, The promoters are A. W. Pollard, L. A. Pollard, Brooklyn; S. O. Loughlin, New York; E. G. Kidder, Williams Bridge, N. Y., and J. B. Cleaver, Bound Brook, N. J.

# Special Correspondence.

## NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, Dec. 22, 1893.

MR. U. T. FACKENTHALL has ceased his connection with the Electrical and Mechanical Engineering and Trading Company, of which he was vice-president and general manager.

MESSRS. HINE & ROBERTSON, 57 Cortlandt street, New York, report the demand for "Straight Line" indicators steadily increasing. "Straight Line is good enough for me," seems to be the popular verdict.

J. W. PARKER & CO., 41 North Seventh street, Philadelphia, Pa., who have ably represented the Ball Engine Company, of Erie, Pa., in that city for years, will also act, after Jan. 1, as their representatives in the city of New York for the sale of "Ball" engines.

A STRIKE was declared in Brooklyn on Dec. 14 against the Electrical Equipment Company as a result of an organized labor fight. The walking delegate, J. P. McMahon, of one faction, declared the strike off, when the workmen of another faction were discharged.

MESSRS. WARREN & BURHORN, 136 Liberty street, have taken the New York and export agencies of the Stearns Manufacturing Company, of Erie, Pa., whose manuafctures include all forms of boilers and wrought iron work, the Gill water tube boiler and Woodbury engines, simple, horizontal and vertical tandem and cross-compound.

## NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 91, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., Dec. 21, 1893.

THE CONTRACT has been let for the extension of its line by the Central Railway and Electric Company from Hartford to New Britain, Conn.

THE BRIDGEPORT (CONN.) CRUCIBLE COMPANY, whose works were destroyed by fire recently, will make arrangements to continue its works in another factory and will rebuild.

THE DEAN STEAM PUMP COMPANY gave notice yesterday to its men that hereafter they would work 16 hours a week, eight on Tuesday and eight on Thursday. The company has been running but four days a week, and the reduction is made on business principles.

THE PHILADELPHIA TRACTION COMPANY has closed a contract with the Westinghouse company for six 1,500-h. p. generators, and two 750-h. p. generators aggregating 10,500 h. p., being the largest cantract ever given foran electric power station. They have also given orders for additional car equipments.

LACONIA CAR COMPANY.—The Laconia Car Company, Laconia, N. H., the largest builders of steam railroad cars in New England, are now building street railway cars of all kinds, electric, cable and horse. The reputation of this company, as builders of the highest grade of car, is sufficient proof that their street railway cars will be of the very best workmanship. Their facilities are unsurpassed for turning out cars at low prices and giving prompt and reliable deliveries. The company employs between 600 and 700 men and has the best skilled labor. Their street railway department will be in the charge of Mr. F. E. Huntress, 8 Oliver street, Boston, Mass. The Laconia Car Company will build, according to specifications, or will duplicate any car now in use, and their prices will probably be such as to commend themselves to all economical and careful railroad officials.

MESSRS. G. M. ANGIER & CO. have succeeded Claflin & Kimball, incorporated as New England agents of the Mather Electric Company, with offices at 116 Bedford street, Boston. During the last two years Mr. Angier has had charge of the selling department of the Mather Electric Company, and its various branch offices, located throughout the United States. He has resigned this position, however, and will hereafter be the active manager of the new firm. The Mather dynamo has been on the market for the past six years, and is in operation in over 1,000 of the largest mills in the country. The Mather dynamo is particularly adopted for large buildings and manufacturing establishments. Mr. C. A Bowditch, who has been favorably connected with the Thomson-Houston and General Electric companies for the last six years, has resigned his position with the General Electric Company and will have charge of the motor department.

## ENGLISH NOTES.

*(From Our Own Correspondent.)*

LONDON, Dec. 12, 183.

INVERTED ARC LIGHTING.—The use of inverted arcs inclosed in large reflectors, sending the light up to white-washed ceilings, is coming into general vogue in this country. Quite recently Messrs. Parsons & Co., of Newcastle, have lighted an entire factory in this way, and the same firm report large orders for similar installations.

ALTERNATE CURRENT INDOOR WIRING.—We still continue to discuss in this country the relative merits for indoor wiring, when alterate currents are used, of automatic earthing devices, earthing one lead or using a conducting sheath between primary and secondary, the conducting sheath being earthed. The fire offices favor the automatic earthing device; wiring contractors seem to prefer to earth the middle of the secondary.

PRESS TELEGRAMS.—According to a statement made in the House of Commons by the Postmaster-General last week the loss upon press telegrams amounts to £300,000 a year. Were this particular loss not incurred, the telegraph department would not only pay its way, but would be able to pay interest on the capital expended by the government in purchasing the telegraph system of the country in 1870, and perhaps also to gradually wipe off arrears of interest.

ELECTRIC LIGHTING TRACTION ENTERPRISE.—The time for advertising new electric and traction schemes expired on Nev. 30. There are only 32 new electric lighting and 13 traction schemes. Of the 32 electric lighting undertakings, 21 are by local authorities and two by gas companies. All the so-called electric traction schemes merely reserve power to use electricity. No notice has been given of any intention to make a regular electric railway or tramway, though, of course, any or all of the 13 schemes, if they come to maturity, may develop into electric ones, since power to do so will have been obtained. There is evidently going to be a pause in the progress of electric traction in this country, and this is, indeed, not surprising, considering that so many schemes have now obtaned parliamentary sanction, but have not as yet come before the public for money. What it is that delays the numerous lines for which powers have been obtained in London, it is difficult to say.

## CANADIAN NOTES.

OTTAWA, Dec. 18, 1893.

OTTAWA, ONT.—The Ottawa Car Company have shipped an electric sweeper to Hamilton, and this week a sweeper will go to Peterboro, together with a specimen vestibule car for the electric railway there.

WOODSTOCK, ONT.—Application has been made to the Ontario Legislature for the incorporation of the Woodstock Electric Street Railway Company, with a capital of $50,000, for the purpose of constructing an electric street railway in that city.

VANCOUVER, B. C.—Messrs. H. P. Dwight, vice-president of the Great Northwestern Telegraph Company, and F. Nichols, of the Canadian General Electric Company, are here inspecting the three electric tramways of Vancouver and New Westminster. It is currently reported that Mr. D. Oppenheimer, the president of the Westminster and Vancouver Electric Tramway Company, is interesting them in a big deal for the purchase of the roads and the introduction of a Great Northwestern Telegraph Company in British Columbia in opposition to the Canadian Pacific.

OTTAWA, ONT.—Last week a 550-h. p. dynamo was put into operation in the Standard Electric Company's station at the Chaudiere. The dynamo is the largest yet manufactured by the Royal Electric Light Company, of Montreal, and has been procured by the Standard company as a reserve power. Before leaving Montreal it was kept running 24 hours with 6,000 lights attached, and was tested at 5,000 volts. There is an indestructible armature in connection with it that is claimed to be proof against burning out. The machine weighs about 30 tons.

# News of the Week.

## ELECTRIC LIGHT AND POWER.

LATHROP, MO., is figuring on a lighting plant.

UTICA, ILL., is making an effort to organize an electric light company.

SANDWICH, ILL., will bond itself to erect an electric lighting plant.

PAWNEE CITY, NEB., is discussing the question of a municipal plant.

VILLISCA, IA.—The village will vote in the matter of electric lighting.

GAINESVILLE, TEX., has granted an electric lighting franchise to E. J. O'Beirne.

CANTON, O., has under consideration the purchase of a municipal plant, to cost $60,000.

NEW ULM, MINN.—The Electric Light Company contemplate putting in of an arc light plant.

FORSYTH, GA.—Residents of Forsyth are agitating for water-works and electric lighting.

TACOMA, WASH.—The municipal plant has recently increased its revenue $1,100 a month.

HARLAN, IA.—The electric light plant has paid about $2,000 indebtedness the past year, besides running expenses.

GENEVA, O.—The Geneva Electric Company has increased its capital stock from $15,000 to $25,000 for improvements.

SOLDIERS' GROVE, WIS.—An electric light plant will be established at Soldiers' Grove. Wm. Manning is interested.

SAVANNAH, GA.—The Governor has signed the bill authorizing the city of Savannah to operate an electric lighting plant.

HYATTSVILLE, MD.—A public meeting is to be called in the matter of bonding the town for $15,000 for sewers and better lights.

JAMESTOWN, N. Y.—The bursting of a pulley in the works of the Jamestown Electric Light and Power Company caused $3,000 damage.

WHATCOM, WASH., is talking of utilizing a 40-foot fall for the generation of electricity for street cars, lighting and manufacturing purposes.

MAYVILLE, WIS., is to have electric lights, an ordinance having been passed by the Common Council of that city granting a franchise to F. Paustain.

MINNEAPOLIS, MINN.—The city engineer and president of the City Council are at work on plans and estimates for a municipal electric lighting plant.

TIFFIN, O.—Judge Seney's contract for lighting the city with electricity has expired, and the Council will advertise for bids for another five years' contract.

LACONIA, N. H., has made a contract for lighting its streets with 2,000-c. p. electric lights, every night from sunset to sunrise for five years, for $95 per light.

SULPHUR SPRINGS, TEX.—Evans & Polk have secured a franchise for water and electric light works, and are ready to correspond with parties wanting to invest.

GENESEO, N. Y.—The matter of electric lights is to come up, as Geneseo is the only village in Livingston County of any pretensions in which the electric light is not used.

MENASHA, WIS.—The City Clerk of Menasha has been authorized to negotiate with the Appleton Electric Light Company in the matter of lighting the city, the present lighting being unsatisfactory.

SCHENECTADY, N. Y.—The chairman of the lamp committee moved that bids be received for the lighting of the city by electric lamps of not less than 1,000 c. p. at the next regular meeting of the Council.

ZANESVILLE, O.—W. D. Chapman is here pushing the interests of the proposed new plant of the Muskingum Electric Company. They have secured an option on the old Beaumont mill building for a power house.

MINNEAPOLIS, MINN.—The City Engineer and the President of the Council are hard at work on the matter of plans and estimates for a municipal lighting plant, and the report to the Council may be expected soon after the first of the year.

HIAWATHA, KAN.—The City Council not having authority to issue bonds to establish an electric lighting plant, it has been suggested that S. C. Davis, I. N. Smith and W. O. Noble, wealthy members of the council, form a company and furnish light.

CHICAGO, ILL.—The Metropolitan Electric Company has bought the electric plant owned by the city on Centre street. It is expected that the city will be able to put up a new building with new machinery at less cost than $100,000. There will, therefore, be left a considerable sum for the extension of the electric lighting system on the west side.

SYRACUSE, N. Y.—The Syracuse Steam Heating Company will apply to Council for a franchise permitting them to furnish electricity as well as steam. If the franchise is granted it will purchase the lot fronting the canal from James street to Canal street, and put up a large plant. It will furnish electric light for East Syracuse, and also power for the Eastwood Heights street railroad.

## THE ELECTRIC RAILWAY.

FREMONT, O.—The Fremont Street Railway has been granted a franchise to equip their line with electricity.

WATKINS, N. Y.—Residents are talking of an electric line between here and Havana, but no definite steps have been taken.

CHURCHTOWN, PA.—A meeting will soon be held in Churchtown to take steps toward the building of an electric road from Mount Holly Springs, via Churchtown, to Mechanicsburg.

HUNTINGTON, L. I.—A number of Huntington capitalists are discussing the matter of an electric railway from there to Cold Spring and Oyster Bay, but no definite action has yet been taken.

FREDERICKSBURG, VA.—Hon. John E. Mason, of King George County, has presented, in the House of Delegates, a bill to incorporate the Fredericksburg and Lancaster Railroad Company.

BROCTON, CHAUTAUQUA CO., N. Y.—O. W. Powell, of Brocton, proposes to build a street railway here. If he can get the franchises and consents, he will have the road in operation by the 1st July, 1894.

NEW BRITAIN, CONN.—A petition has been received from the Central Railway and Electric Company for leave to extend their lines to the Berlin town lines, they agreeing to use 50-pound T rails on chestnut ties.

LOWELL, MASS.—Eben Moody Boynton, H. H. Mawhinney and others, representing the Boynton Bicycle Railway Company, have applied for permission to build and operate a bicycle road in Lowell and nearby towns.

NEW BRUNSWICK, N. J.—The Board of Aldermen will act as a committee on the whole on Dec. 20 at 8 p. m. to consider the advisability of granting a franchise to the city railroad company, allowing them to introduce electricity.

RANDALLSTOWN, MD.—The following are the committee which is moving in the matter of the proposed road from Baltimore to Randallstown: Emory George, Albert Weber, Henry S. Jean, Chris Hidey and Henry G. Lutgerding.

FALLS CHURCH, VA.—A public meeting of citizens will be held to consider the question of bonding the city for $10,000 to aid any responsible company that will build and equip an electric road from Falls Church to Washington.

PITTSBURGH, PA.—It is stated, on good authority, that the Second Avenue Electric Railway, of Pittsburgh, which is to build a bridge at Glenwood, in order to get into Homestead, will extend its line to Mendelssohn and Glassport, and eventually to McKeesport.

FLATBUSH, L. I., N. Y.—The Highway Commissioners of the village of Flatbush have granted a franchise to the Brooklyn City Railroad Company for a trolley line through Flatbush. The road is to be three miles or more long, and the company agrees to have it done by July 4 next.

MIDDLETOWN, N. Y.—Meetings are to be held at Middletown, Liberty, Youngsville and Jeffersonville, in the matter of the proposed electric road between Liberty and Jeffersonville. It is stated that the road can be built for $12,000, and residents will be asked to subscribe for bonds. S. P. Kellogg and J. C. Clirehugh, of Elizabeth, N. J., are moving in the matter.

HARTFORD, CONN.—The contract for building the electric road from the limits of Hartford to New Britain and Unionville has been awarded to the Hartford and West Hartford Electric Road Company, of which David Henney, of Hartford, is president, and W. E. Goodwin, of Elmwood, is secretary. The contract calls for completion of the work by April 1, 1894.

ABERDEEN, MD.—The Town Commissioners of Aberdeen have granted a franchise to the Automatic Electric Company for an electric railway and electric lights. The citizens of the town will subscribe $30,000 to the capital stock of the railway company for the purpose of building a road from Aberdeen to Glenville, at which place it will meet the main line, and thence to the Susquehanna paper mills.

THE SOUTH DAKOTA RAPID TRANSIT AND RAILWAY COMPANY, SIOUX FALLS, S. D., have recently elected the following officers: President, W. R. Kingsbury; vice-president, C. W. Hubbard; secretary, J. H. Voorhees; treasurer, F. H. Files, M. D.; superintendent, R. L. Wells; attorneys, Bailey and Voorhees; directors, W. R. Kingsbury, C. W. Hubbard, J. H. Voorhees, F. H. Files, C. O. Bailey, R. L. Wells, S. G. Tuthill.

HEMPSTEAD, L. I., N. Y.—The Brooklyn Traction Company has secured a 30-day option of 1,240 shares of the Jamaica and Hempstead Plank Road Company, and Thomas H. Clowes, secretary of the Plank Road Company, states that the traction company wishes to extend its Jamaica line to Hempstead. It is likely that a trolley line will be running by Jan. 1, 1895. The franchise of the Plank Road company does not provide for a railway, but it is stated that there will be no trouble in getting one.

BRIDGETON, N. J.—The Bridgeton, Cedarville & Port Morris Railway Company and the West Side Railway Company have been organized to build electric railways in Bridgeton with the same incorporators, as follows: Osgood Welsh, of New York; Wm. Welsh, Jr., of Philadelphia, Pa.; J. Pemberton Newbold, of Philadelphia, and Chas. R. Newbold, Thos. U. Harris, John Smalley, Wm. O. Garrison and Walter H. Bacon, of Bridgeton. The latter is secretary-treasurer of the two companies. They have applied for a franchise.

## LEGAL NOTE.

LAMP INFRINGEMENT SUITS.—Suits have been filed in the United States Circuit Court for the Eastern District of Pennsylvania by Richard N. Dyer and C. E. Mitchell, of counsel for the Edison Electric Light Company, of New York, and Samuel B. Huey, solicitor for the Edison Electric Light Company, of Philadelphia, against the following respondents: The Manufacturers' Club, of Philadelphia; the Philadelphia Trust, Safe Deposit and Insurance Company, trustee under the will of John Crump, deceased, owners of the Colonnade Hotel, and George J. Crump and Henry J. Crump, lessees, and against the Spreckels Sugar Refining Company, a corporation doing business in the city of Philadelphia. The object of these suits is not only to restrain the said defendants from continuing the purchase and use of incandescent lamps, which have been adjudged by decisions in various United States Courts to infringe upon the patents of Thomas A. Edison, but to compel an accounting for the purchase and use of infringing lamps in past years. Voluminous bills of complaint have been filed by the plaintiffs reciting the decisions which have been obtained against infringing manufacturers, and accompanied by affidavits from Thomas A. Edison, the inventor of the incandescent lamp; Jacob H. Herrick, president of the Edison Electric Light Company, of New York; William D. Marks, president of the Edison Electric Light Company, of Philadelphia; George F. Barker, Professor of Physics in the University of Pennsylvania; John W. Howell, electrician of the Edison Lamp Works, and James T. Maxwell, general agent of the Philadelphia Edison company. It is the avowed intention of these companies to push these suits vigorously, and the results will be of interest to all other users of lamps infringing the Edison patents.

## MISCELLANEOUS NOTES.

CORNELL UNIVERSITY has 322 students in electrical engineering.

A STAY BY TELEPHONE.—Judge Herrick, of Albany, recently granted a stay in a murder case, which was repeated by telephone and served.

IS THIS A JOB?—A St. Joseph (Mo.) paper says that the city electrician reports that new dynamos will be needed to replace a number that are worn out. The worn-out dynamos have been in use for four years and are of a standard make.

THE FORT WAYNE (IND.) "JOURNAL" says that the Fort Wayne Electric Works are busy for the first time in the last few months. The electric works have plenty of work now and expect hereafter to work six full days every week. New men will soon be employed and steady employment for the winter is assured to many skilled workmen.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.—At a meeting of the Committee on Arrangements, held in Washington, Dec. 19, the Ebbitt House was selected as headquarters of the association. The meetings will be held in Grand Army Hall, 1412 Pennsylvania avenue, within one block of the hotel, on Feb. 28, March 1 and 2, 1894.

THE NATIONAL BROTHERHOOD OF ELECTRICAL WORKERS has elected the following officers for the ensuing six months: President, Joseph P. Meloney; vice-president, John J. Tracy; recording secretary, Daniel F. Cronin; financial secretary, Charles E. Byrne, treasurer; T. F. Herbert; inspector, Thomas Cronin; foreman, Christopher Johnson; press secretary, Daniel F. Cronin; trustees, O. W. Chaffee, Jr.; C. L. Spencer and T. O'Leary.

THOMSON-HOUSTON RELIEF ASSOCIATION.—The employees of the Thomson-Houston Electrical Works, at Lynn, have formed a relief association and issued announcements of the purpose of the organization throughout the works. The main idea is to relieve the suffering of the unemployed workmen, if there are any, and to provide for whatever may occur in the future. The committee will begin work at once and solicit contributions from the men now employed in the works.

PROF. WILBUR M. STINE, director of the department of electricity of the Armour Institute, Chicago, in addition to his other duties, will have editorial charge of the monthly magazine "Electrical Engineering," and of the monthly summary of current technical literature, which heretofore has borne the title of De Land Synoptical Index, but hereafter to be published under a separate cover bearing the title of "Electrical Literature." Mr. Fred De Land will retain the business management of both publications.

THE JOHN SCOTT LEGACY MEDAL AND PREMIUM, held in trust by the city of Philadelphia, under the legcay of John Scott, of Edinburgh, to be used for the encouragement of "ingenious men and women who make useful inventions," provides for the distribution of a medal inscribed "To the Most Deserving," and a money premium in the sum of $20, has just been awarded to Jarvis B. Edson, of New York, for a pressure recording gauge, by the Franklin Institute, who have been delegated by the Board of City Trusts, of Philadelphia, to make investigations and awards.

THE SAME OLD CHESTNUT.—Under this caption the Peoria (Ill.) "Journal" has the following, after a quotation from a Boston paper detailing Pennock's latest move: "This is the same Pennock and the same 'system' that was, years ago, instrumental in fooling John Hall and the old Fort Clark Street Car Company into believing it possible to run motors by electric 'voltage' process at a cost of a single fare per day. When the people of Boston have as much practical experience with Pennock stock jobbing as some Peorians have, they may not be as rich as they are now, but they will know a heap more about the cost of electric operations."

STREET RAILWAY RECOMMENDATIONS.—The New York Electrical Subway Commissioners in their annual report, say: "In the opinion of this board, the regulation of the speed is of more urgent necessity than the adoption of an appliance which shall trip and catch or pick up a citizen who is on the track. It is of importance to note that two lives have been recently lost by the impact of a car. The victim was not injured by the wheels. Such safety devices as have been thus far offered would prove lastingly serviceable only under the condition of a perfectly level and smooth pavement between the rails and for a little distance outside of them. A continuously tinkling bell is also much needed as an additional warning, especially in the busier thoroughfares. Regulation of the speed can probably be accomplished only by a mehcanical governor which will limit the rate of the motor to that required to propel the car to a maximum velocity."

## Trade and Industrial Notes.

JOHN B. WHALEN, & CO., of Sycamore, Ill., are moving into their new factory just completed.

PROF. CLEMENT PAYEN, the electrician, is in the city, says a Minneapolis paper, completing arrangements for the establishment of a plant to manufacture all kinds of electrical appliances. Hundreds of skilled electricians, it is stated, will be employed.

THE C. & C. ELECTRIC COMPANY, which has been reorganized, will have its general offices at 143 Liberty street after March 1, 1894. The new works at Garwood, N. J., on the New Jersey Central Railroad, are well situated and very complete in all their appointments.

THE DENISON (TEX.) LIGHT AND POWER COMPANY has just put in an 18 by 36 Reynolds-Corliss engine manufactured by the E. P. Allis Company, of Milwaukee, and also a full complement of shafting, friction clutch pulleys, etc., made by the Hill Clutch Works, of Cleveland.

THE JEFFREYS MANUFACTURING COMPANY, of Columbus, O., has ready for distribution a complete catalogue, showing full size illustrations of every chain link made by it. It also includes a complete price list of its specialties, and will be of value to all users of material in their line.

LANGSTAD, PETERSON & CROSWELL, of Appleton, Wis., is the official title of a new firm which has been formed by a consolidation of the interests of the electrical firms of Langstad & Peterson and M. H. Croswell. The new firm has secured quarters at 767 College avenue, and are prepared to do all kinds of the electric wiring for lighting and other purposes.

THE AUGUSTA (GA.), EXPOSITION, which has been open since Nov. 15, closed on Dec. 15. The Fort Wayne company exhibited an arc dynamo and alternator, and Mr. R. J. Edenfield, of Augusta, had an attrcative display of electric machinery and artistic lighting. The exposition building and grounds were well lighted by arc and incandescent lights from the local Thomson-Houston company's lines.

THE CLEVELAND (O.) MACHINE SCREW COMPANY reports that the fire which visited its finishing department on Dec. 18 is not so serious as at first supposed. It will have no difficulty in repairing the damage at once, and expect to be in full operation in the course of a week or ten days, and asks the indulgence of customers with the assurance that everything possible will be done to forward their orders at the earliest possible moment.

THE CENTRAL ELECTRIC COMPANY is finding an immense sale for its colored incandescent lamps, these being greatly in demand for holiday displays. The lamps supplied by this house are particularly adapted for this purpose. The glass used in their manufacture is genuine colored glass, not dipped. This makes it possible for them to burn out of doors in all sorts of weather. The company also reports a constantly increasing demand for the Varley dust-proof bell. This bell has already been described in the columns of The Electrical World, its chief feature being india rubber attachments which prevent dust penetrating the interior.

THE MASON REGULATOR COMPANY, Boston, on Jan. 1, will make an addition of three new books to their popular engineering series. No. 4, "Electricity for Engineers." This is a practical treatise written in concise language and without any formulae, for the use of engineers who have an electrical plant under their charge. It also contains one feature which will be of value to any contracting engineer, namely, the complete revised rules of the Underwriters' Union, for the installation of electrical plants. No. 7 of this series is an "Engineers' Log Book," for keeping a scientific record of the performance of engines and steam plants, and No. 8 a "Chief Engineers' Record Book," adapted for the use of chief engineers.

PEPPER & REGISTER, Chestnut and Fourth streets, Philadelphia, have the contract for the overhead construction work of the Philadelphia Traction Company, which amounts to over 136 miles, and have just closed a contract with the Electric Traction Company, of Philadelphia, whose line is about 124 miles in length, and a contract in Lynchburg, Va., to build an electric railway there, including the laying of tracks, paving streets, and overhead construction. They have recently, in connection with their business, taken the agency for the J. H. McEwen Manufacturing Company, Ridgway, Pa., manufacturers of high grade automatic engines, and are pushing the sale of the engine in their locality.

THE WALKER MANUFACTURING COMPANY, Cleveland, O., has issued three elaborate bound catalogues of its various lines of metal manufactures, one being devoted to power transmission machinery, another to hydraulic and cable machinery, and a third to gears, and containing 194, 186 and 312 octavo pages, respectively. The binding is especially neat, being black cloth, with rounded corners, the corners of the book being also rounded and the edges colored red. The different volumes are profusely illustrated, and each has a valuable section, containing engineering notes, embracing data and formulae on gears, pulleys, flywheels, shafting, belting, strength of materials, hydraulics, friction, transmission of power by ropes, etc.

## Business Notice.

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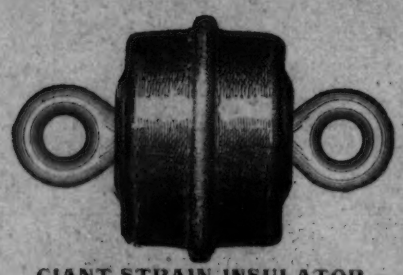

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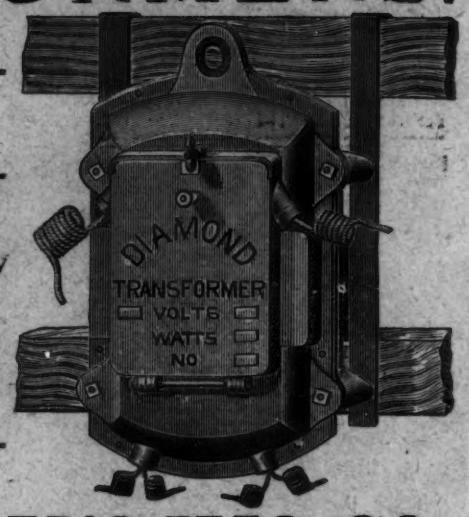


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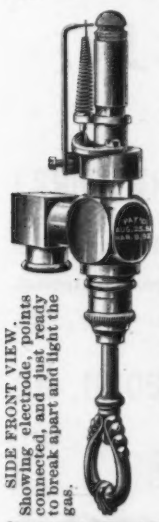


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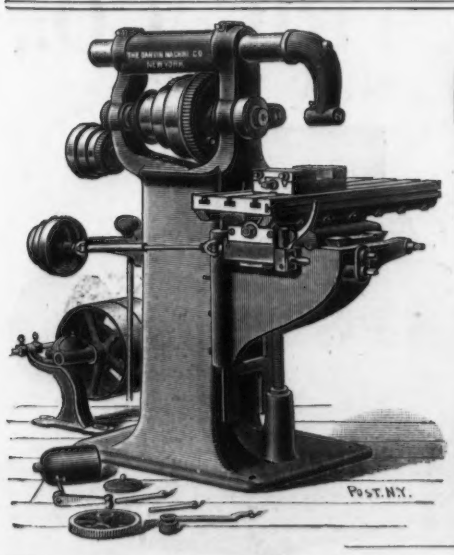

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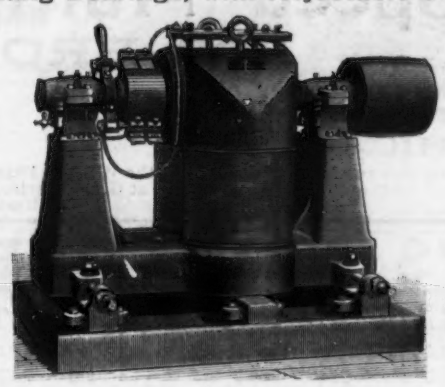

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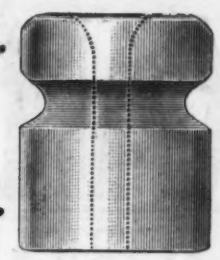

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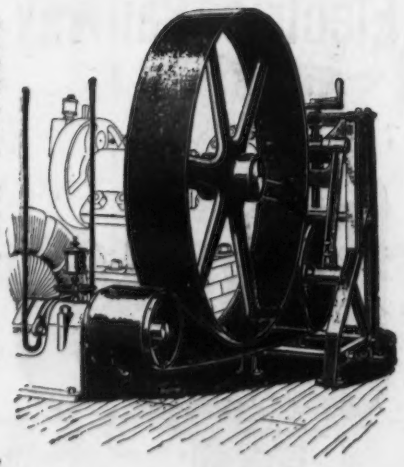

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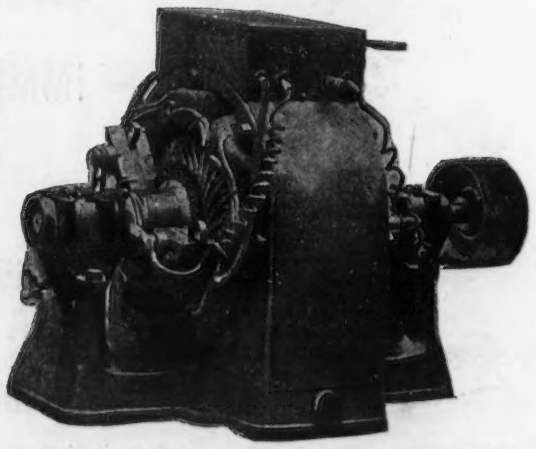

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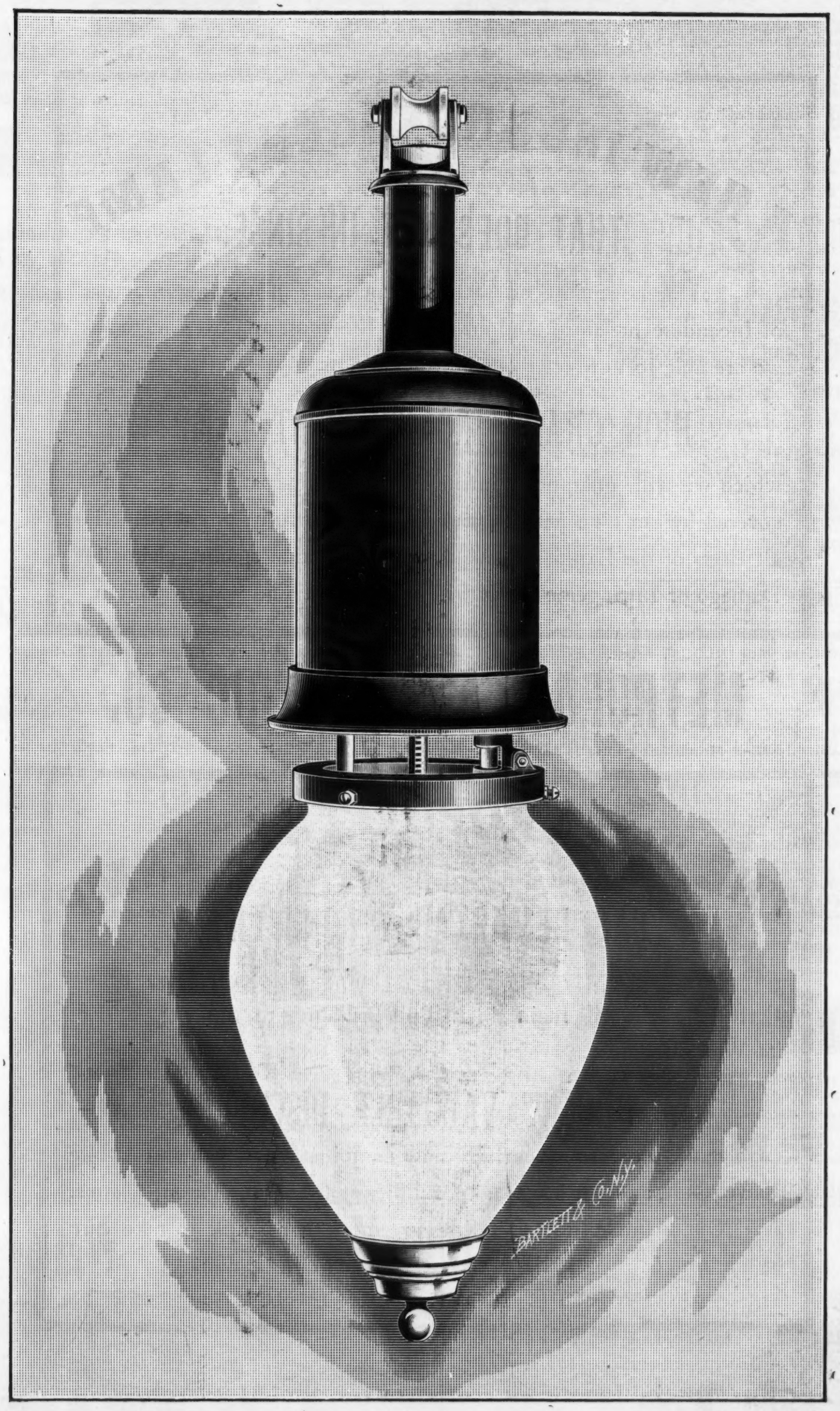


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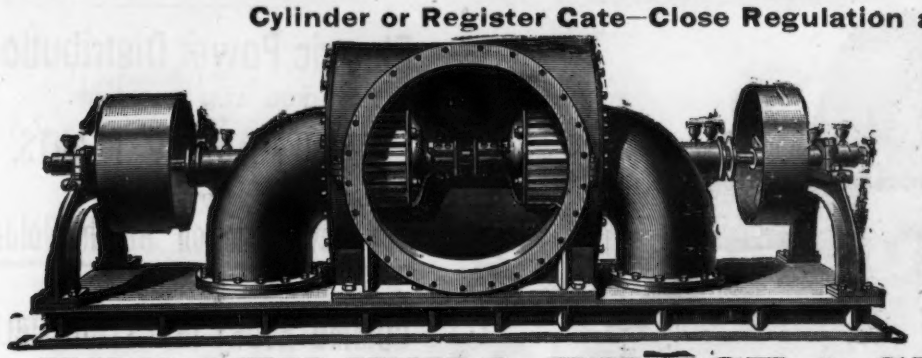

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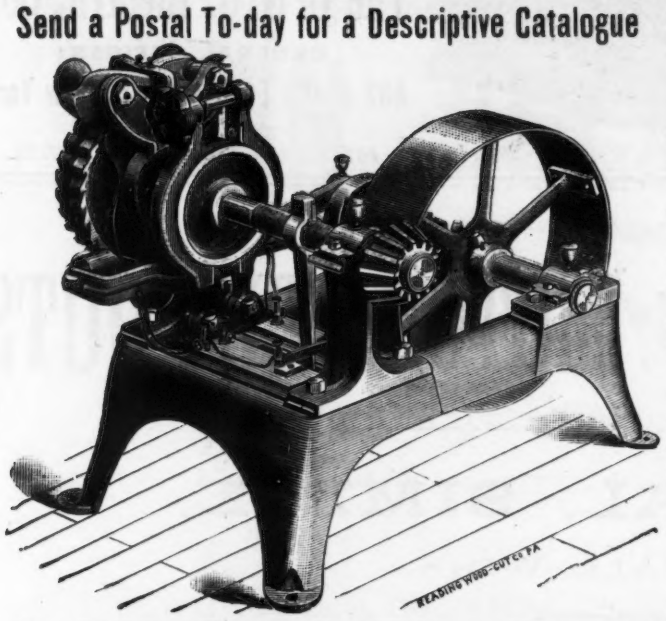

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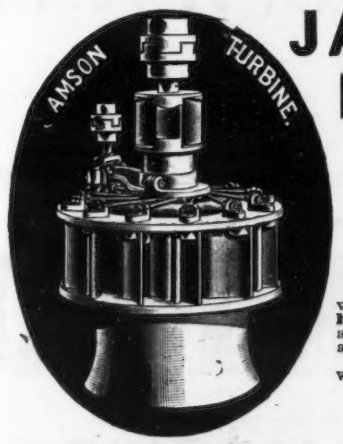


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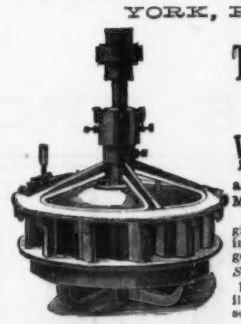

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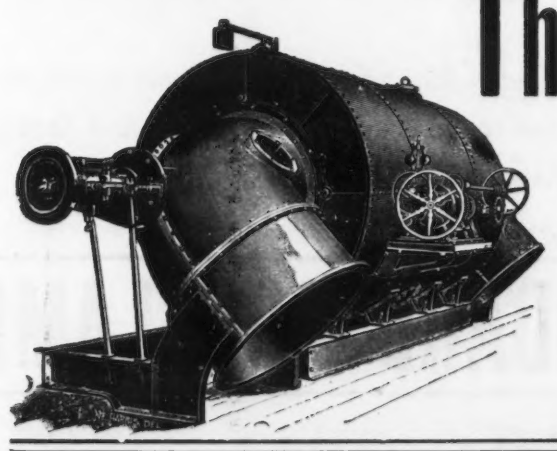

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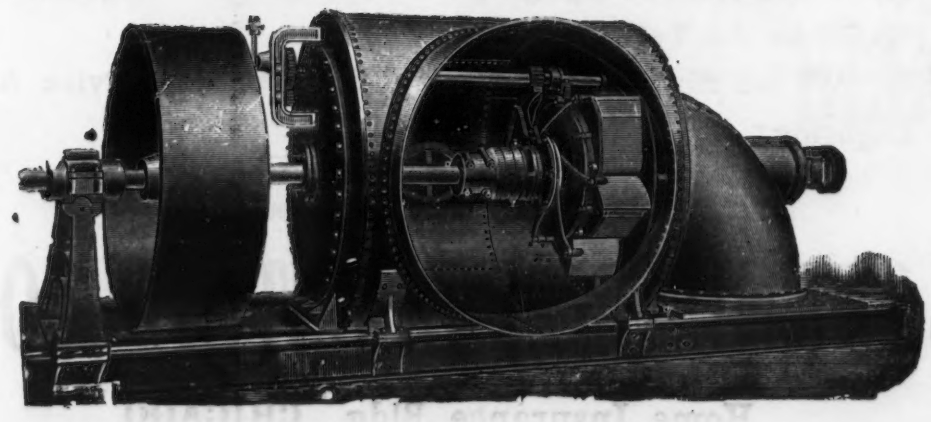

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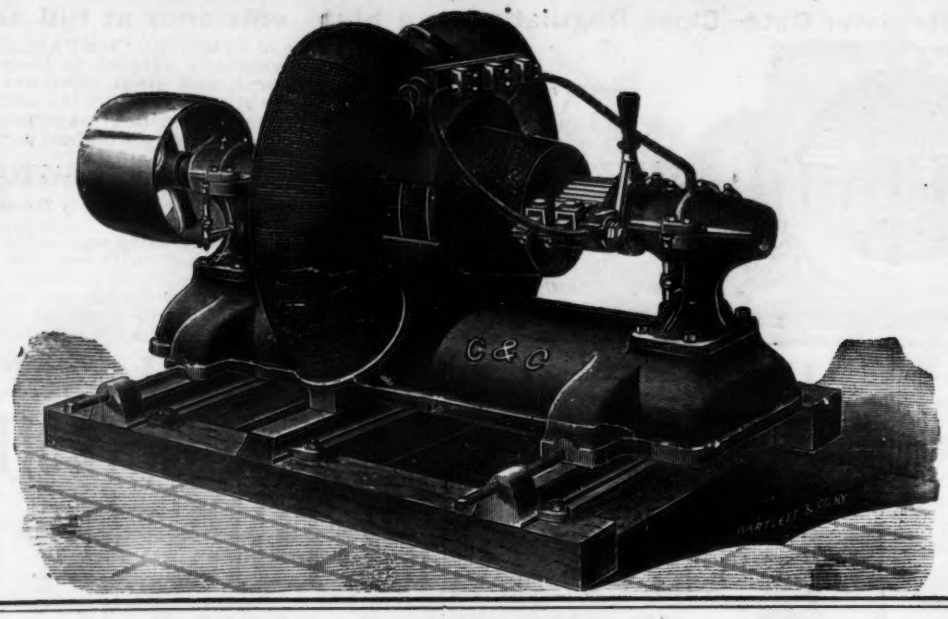

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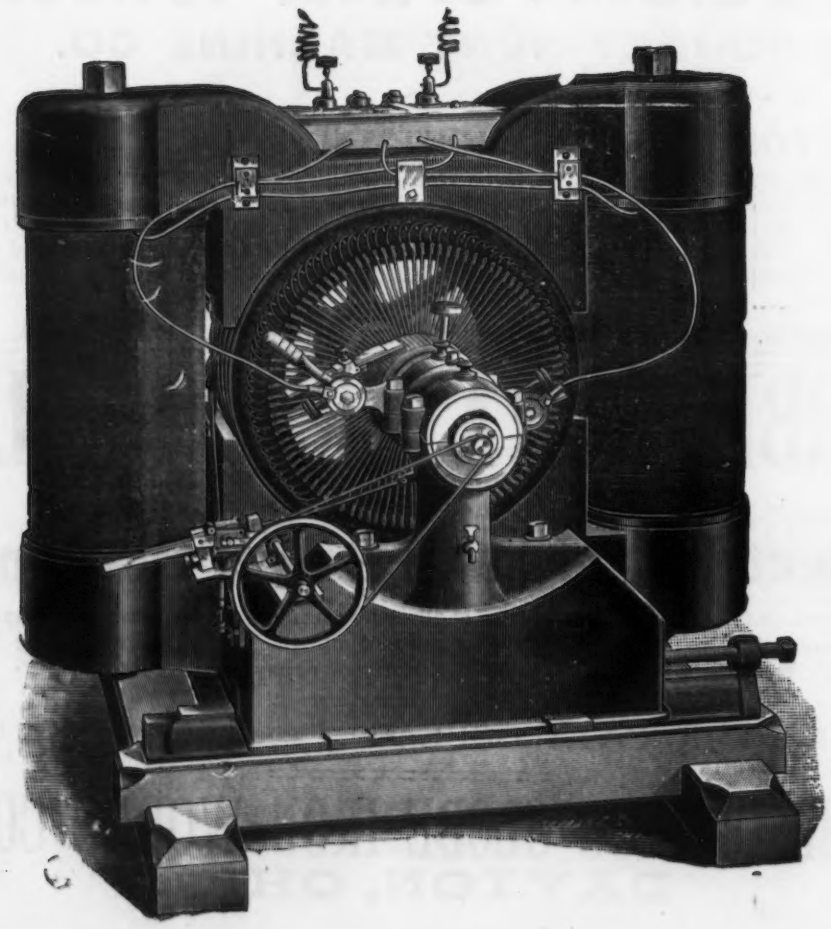

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**The two largest** contracts ever made in this country for **Incandescent Electric Lighting Machinery—The World's Fair** plant and the plant for the **Louisville Gas Company**—were both awarded to the Westinghouse Company, and the installations furnished with **Westinghouse Alternating Current Apparatus.**

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**The largest street railway companies in Brooklyn, Jersey City, Philadelphia, Pittsburgh, Chicago, Cincinnati, Indianapolis** and **St. Louis** have equipped their systems with **Westinghouse Electric Railway Apparatus.**

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# WESTINGHOUSE ELECTRIC & MFG. CO.

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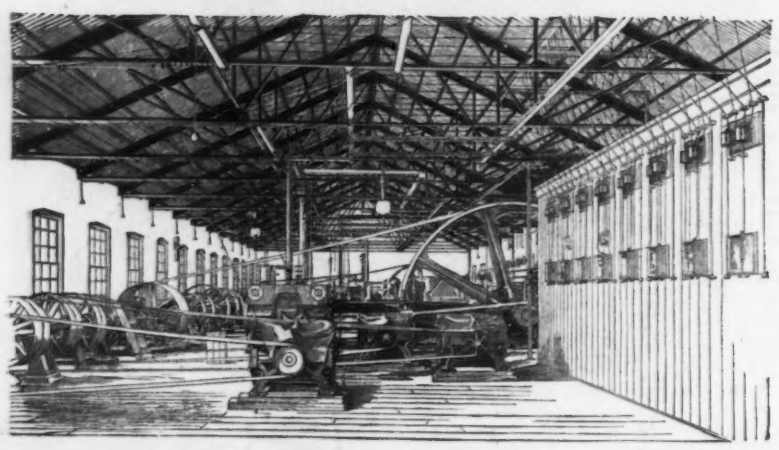
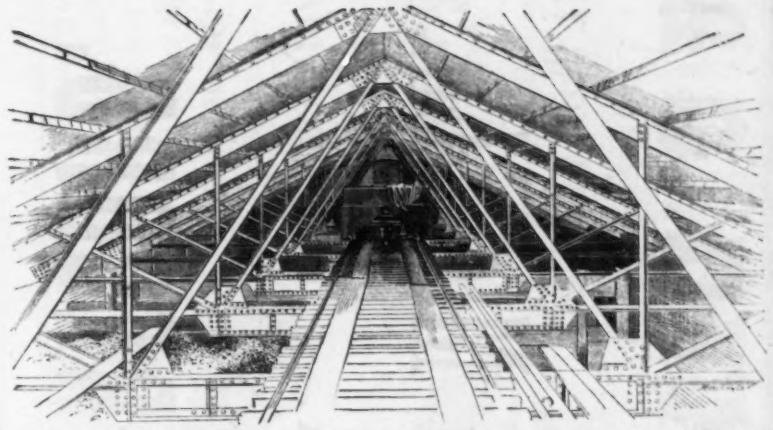
## Engineers, Architects and Builders of Iron and Steel Bridges and Buildings.

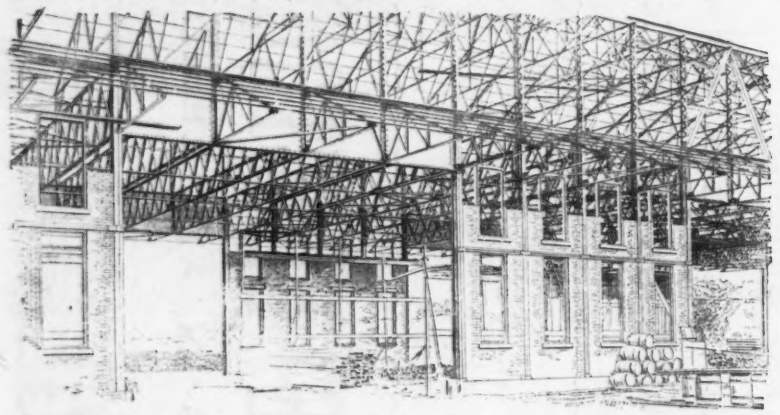


The above illustration is taken direct from a photograph, and shows the construction of an Iron Truss Roof designed and built by us for The Connecticut Electric Co., at Waterbury, Conn. The building is 51 ft. in width by 251 ft. in length, with brick walls and iron truss roof covered with corrugated iron. For an Electric Light Station, where the risk from fire is very great, this construction particularly commends itself, as the risk from fire is entirely eliminated.

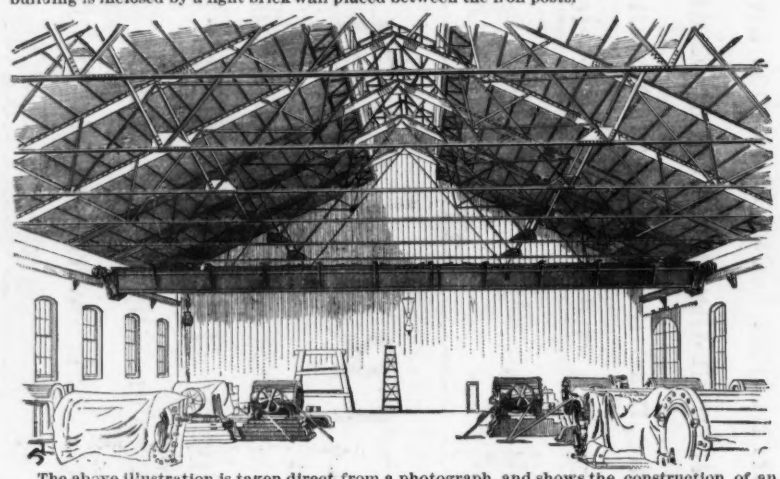
The above illustration is taken direct from a photograph, and shows the interior of a Pulp Mill designed and built by us for The Manufacturing Investment Co., at Madison, Maine. The photograph is taken in the basement, so as to show the construction of the iron posts and iron girders supporting the floors. The entire framework of the building is made of iron, and the heavy loads of pulp, paper, etc., are carried entirely by these iron posts and girders. The building is inclosed by a light brick wall placed between the iron posts.



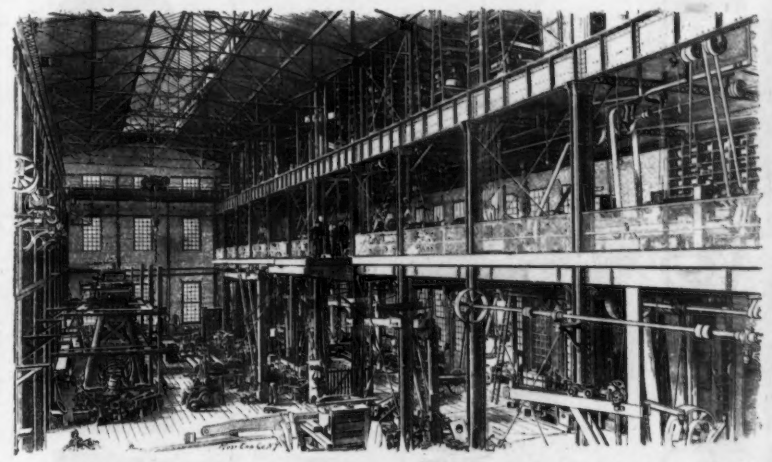
The above illustration is taken direct from a photograph, and shows an Iron Truss Roof designed and built by us for The Burlington City Water Works, at Burlington, Vt. The building is used for storing coal, and the roof is designed to carry a track through the trusses, so that the coal can be distributed from the trusses, and thus save handling. The roof is entirely of iron, no woodwork being used about the construction in any way, shape or manner, it being absolutely fireproof.



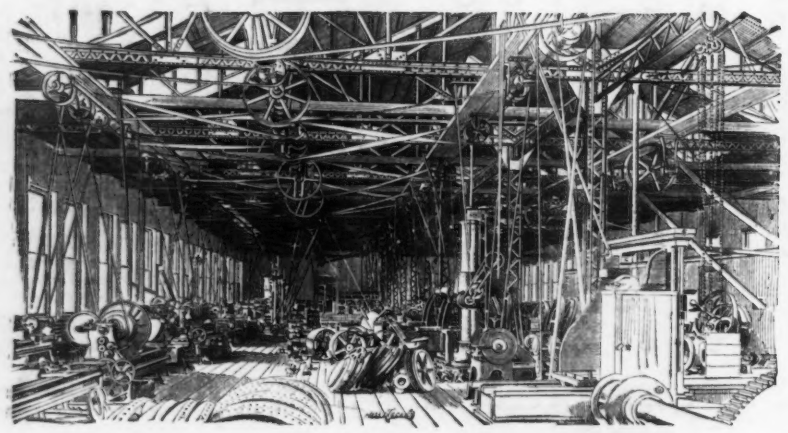
The above illustration is taken direct from a photograph made during the construction, and shows the details of an Iron Building designed and built by us for The Newport News Shipbuilding & Dry Dock Co., at Newport News, Va. The building is 60 ft. in width by 320 ft. in length, and is two stories high—the lower floor being used as a Ship Shed for punching, bending, riveting, etc.—the upper floor being used as a Mold Loft. Outside of the building, extending entirely around it on all four sides, is an overhang 12 ft. wide, thus affording additional shop room outside of the building, where raw material may be stored and still be protected from the weather. Wide openings are placed every 40 ft., so that raw material may be taken in and finished product moved out, cheaply and quickly. The supporting frame is all iron throughout, and between the iron posts on the sides is a light brick wall.



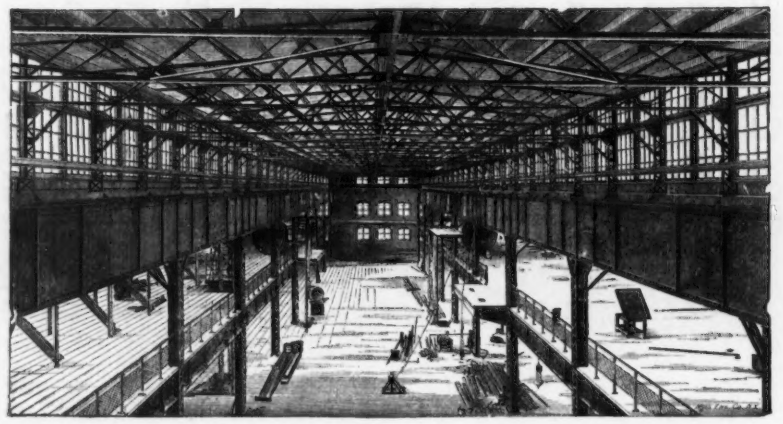
The above illustration is taken direct from a photograph, and shows the construction of an Iron Truss Roof with a Traveling Crane, both of which were designed and built by us for The Narragansett Electric Lighting Co., at Providence, R. I. The illustration is taken in the Dynamo Room, which is 60 ft. in width by 200 ft. in length. The side walls are of brick, with Iron Roof Trusses covered with our Patent Anti-Condensation Corrugated Iron. This is the first roof ever built with this Patent Anti-Condensation Corrugated Iron, and after passing through three severe winters has shown no signs whatever of any dripping or sweating on the corrugated iron. We guarantee this Anti-Condensation Corrugated Iron Roof Covering not to drip in the coldest weather.



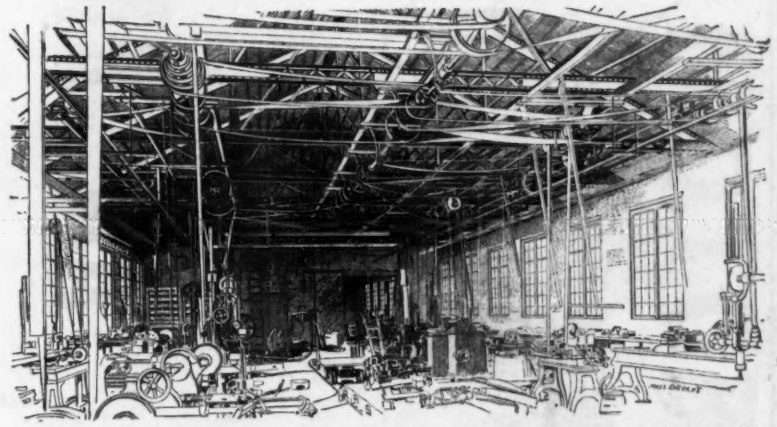
The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop designed and built by us for The Dry Dock Engine Works, at Detroit, Mich. The central portion, or Erecting Room, is 40 ft. wide, with a gallery three stories high on one side, this gallery being 27 ft. in width. The upper floor of the gallery is used for storing patterns, while the second floor is used for light machine work and the lower floor for heavy machine work—this lower floor being controlled by jib cranes, which also swing out into the central portion, thus delivering material from the wings by means of the jib cranes and the traveling crane to any portion of the Erecting Room. The whole framework of the building is of iron, with brick filling for the side walls.



The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop, the roof of which was designed and built by us for The Titusville Iron Co., at Titusville, Penn. The building is 70 ft. in width by 205 ft. in length. The roof trusses are made entirely of iron and designed to carry shafting. Through the centre of the building is a row of wrought iron columns. Machine shop roofs built after this plan are not only much neater in appearance than heavy cumbersome wooden trusses, but are stronger and stiffer; and where no wood is used about the construction the danger from fire is entirely eliminated.



The above illustration is taken direct from a photograph, and shows the construction of a Machine Shop designed and built by us for The Link Belt Machinery Co., at Chicago, Ill. The building is 124 ft. in width by 407 ft. in length. Each side wing is 42 ft. in width and two stories high. The central portion of the building is 50 ft. in width, controlled by a hydraulic crane with a travel the full length of the building. This is probably one of the best designed modern Machine Shops to be found in the United States.



The above illustration is taken direct from a photograph, and shows the construction of an Iron Truss Roof designed and built by us for the C. W. Hunt Co., at West New Brighton, Staten Island, N. Y. The building is 42 ft. in width by 202 ft. in length, and is used by The C. W. Hunt Co. as a Machine Shop. The side walls are of brick and the roof trusses of iron, with iron purlins covered with slate, so that no woodwork is used about the construction of the building in any way, shape or manner, thus eliminating entirely the danger from fire. This is one of the best designed and equipped Machine Shops of its size in the United States.

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# THE BERLIN IRON BRIDGE CO.

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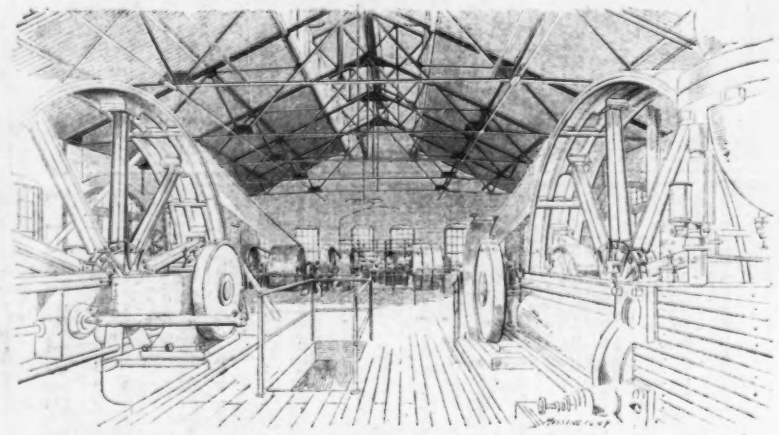
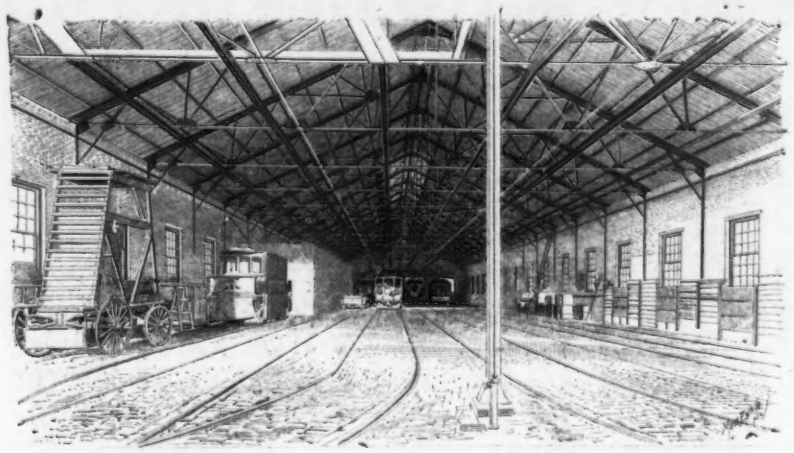
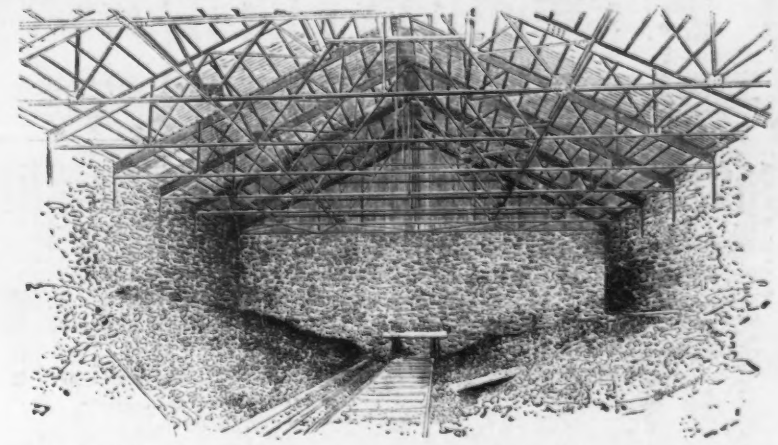


The above illustration is taken direct from a photograph, and shows the interior of a Dynamo Room, the roof of which was designed and built by us for The Mather Electric Company, at Manchester, Conn. The building is 52 ft. in width and 151 ft. in length.

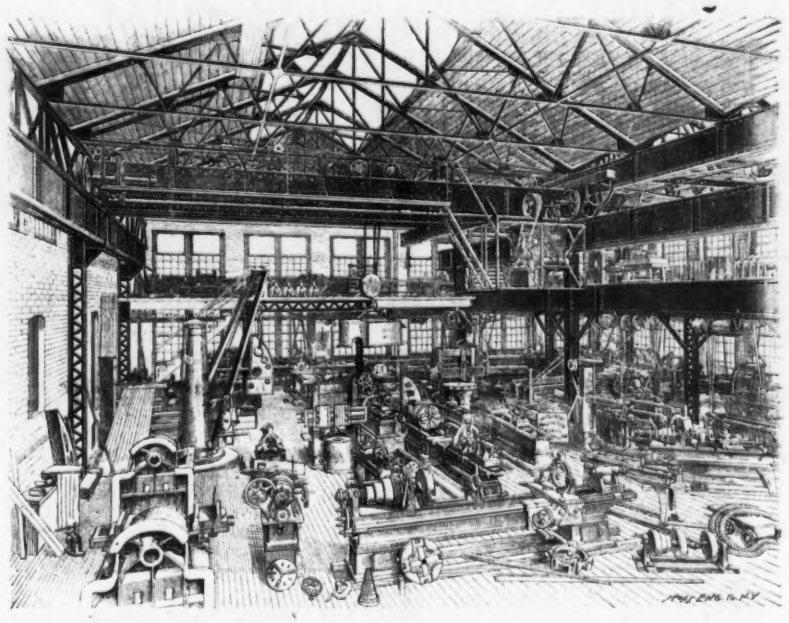


The above illustration is taken direct from a photograph, and shows the interior of a Car Shed designed and built by us for The Wilmington City Railway Company, at Wilmington, Del.

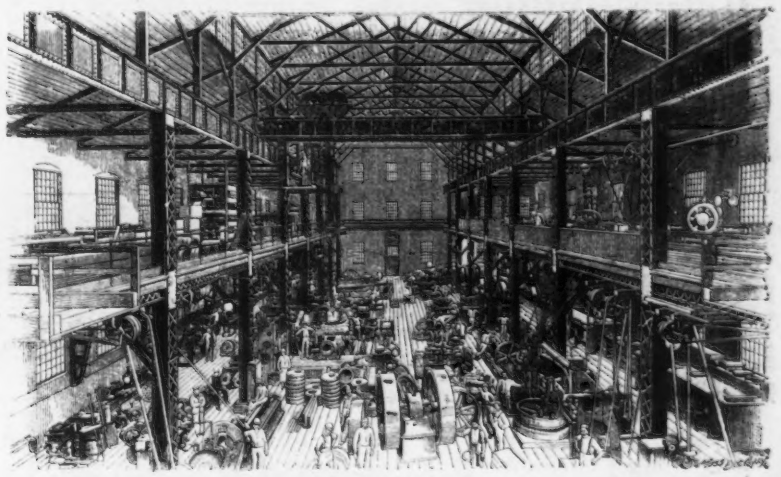


The above illustration is taken direct from a photograph, and shows the interior view of a Stock House designed and built by us for the Isabella Furnace, at Barneston, Pa. The building is 54 ft. in width, by 101 ft. in length, the side walls being of stone, with an iron roof covered with corrugated iron. No woodwork being used about the building in any way, shape or manner, it is absolutely fireproof, there being nothing about it which can burn or take fire.

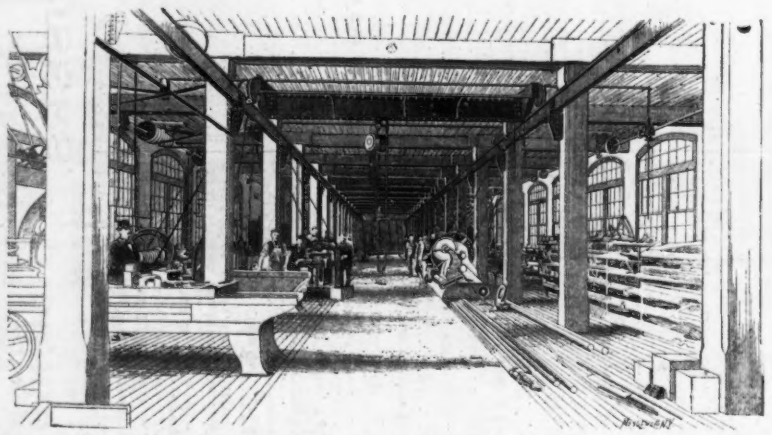
The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop designed and built by us for The Mather Electric Company at Manchester, Conn. The building is 52 ft. in width and 151 ft. in length.



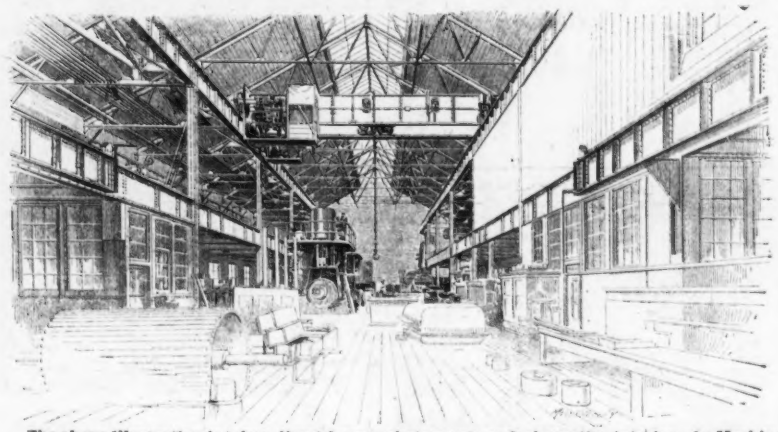
The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop designed and built by us for The Bridgeport Machine Tool Company, at Bridgeport, Conn. The building consists of two parts, each 40 ft. in width. That shown in the immediate foreground being one story high for erecting room, while that portion of the building shown on the right is two stories high, light work being done on the second floor.



The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop designed and built for our own use at East Berlin. The construction particularly commends itself on account of the large amount of wall space applicable for storage purposes, the light being introduced entirely from the roof, no side windows being used, thus allowing all the wall space for storage.



The above illustration is taken direct from a photograph, and shows the construction of a Traveling Crane placed by us in the Machine Shop of the National Meter Company, at Brooklyn, N. Y. The building is the usual construction of brick walls, with wooden posts supporting wooden floors. The crane girders are attached to wooden posts, and the crane has a travel the full length of the building between the posts. The plan commends itself where parties desire to control a limited floor space in a building already built.



The above illustration is taken direct from a photograph, and shows the interior of a Machine Shop designed and built by us for The J. Morton Poole Co., at Wilmington, Del. The building is 87 ft. in width, by 135 ft. in length. The central portion of the building is 36 ft. in width, and of sufficient height to set up heavy marine engines under the traveling cranes.

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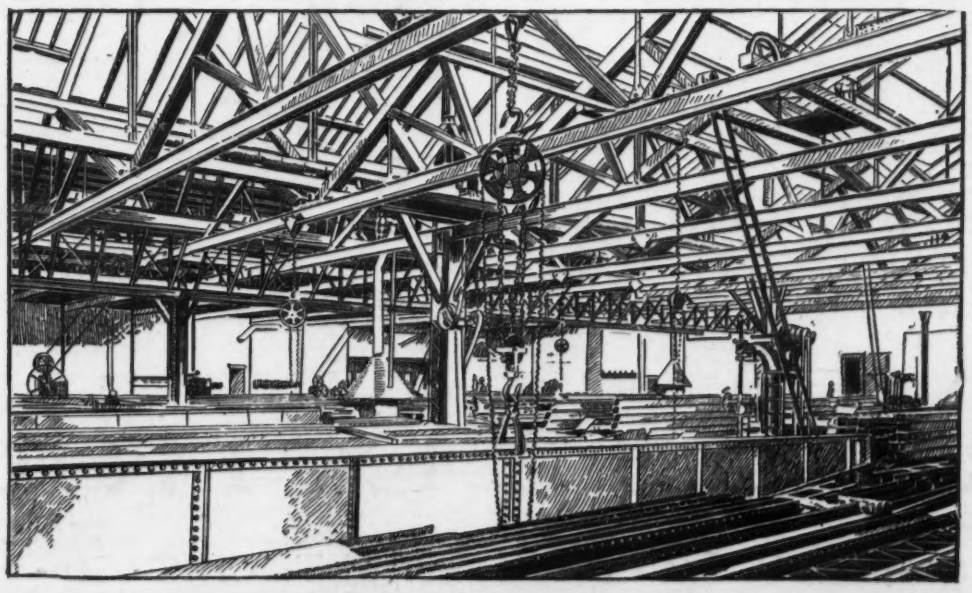

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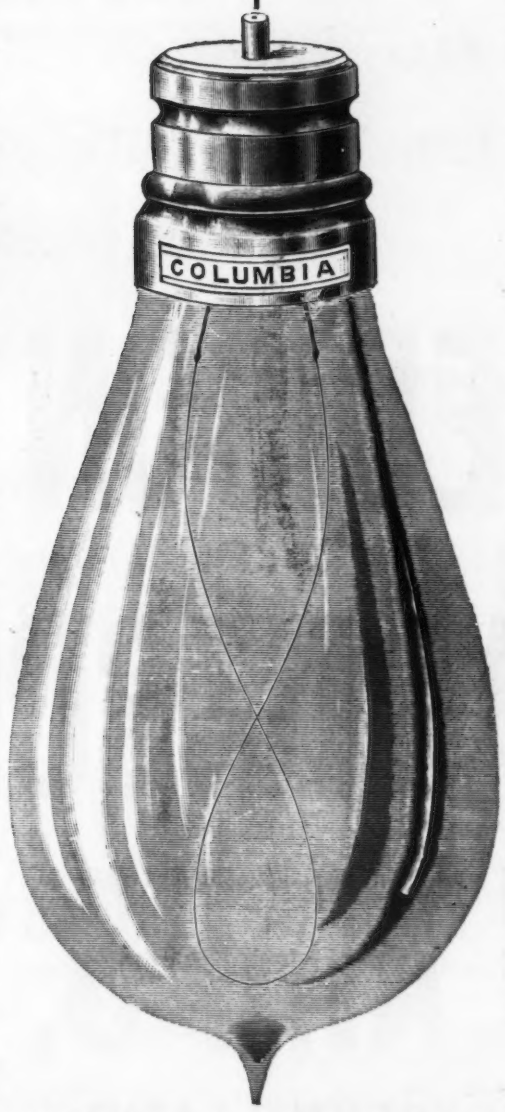


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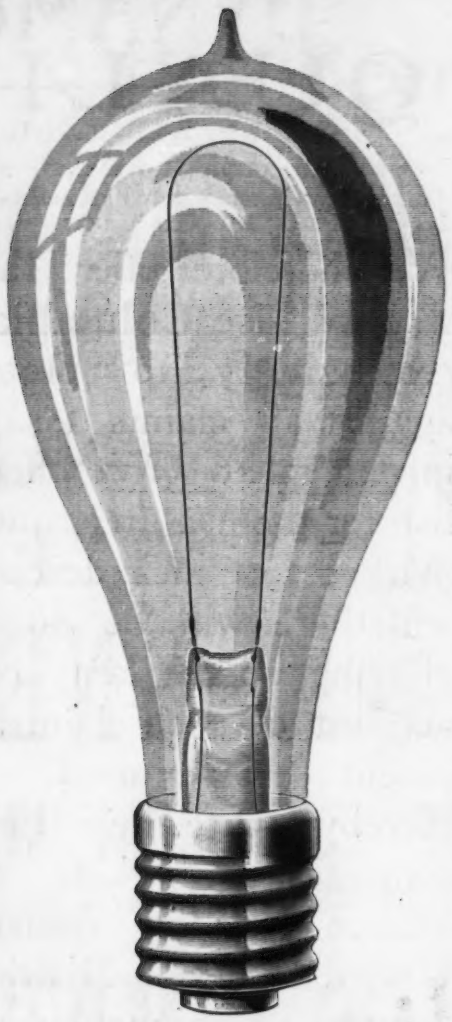

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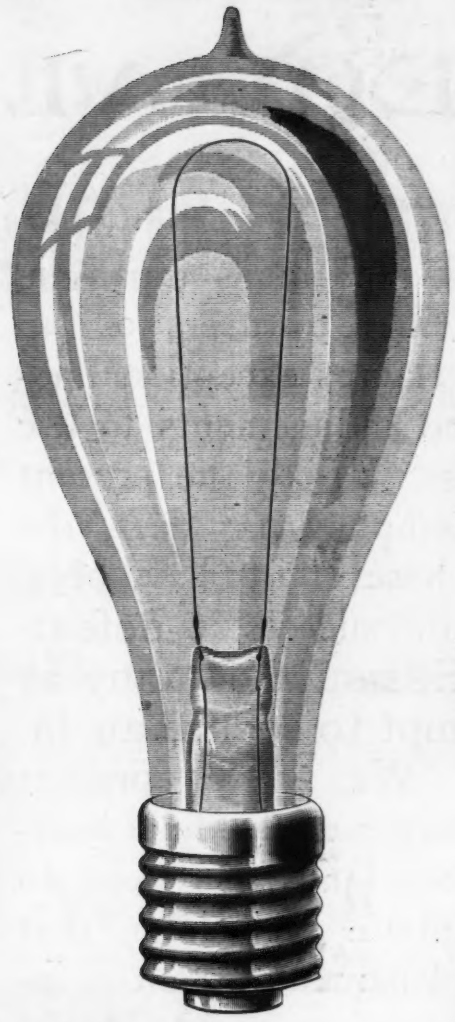

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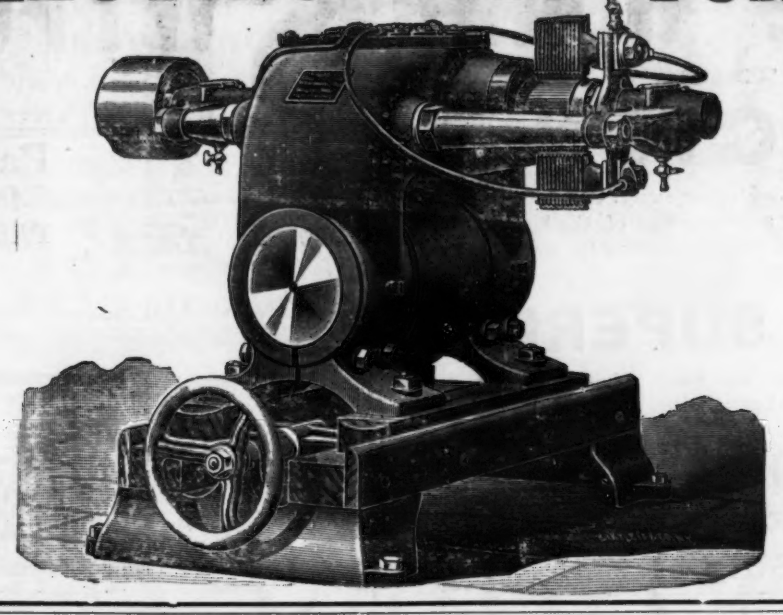

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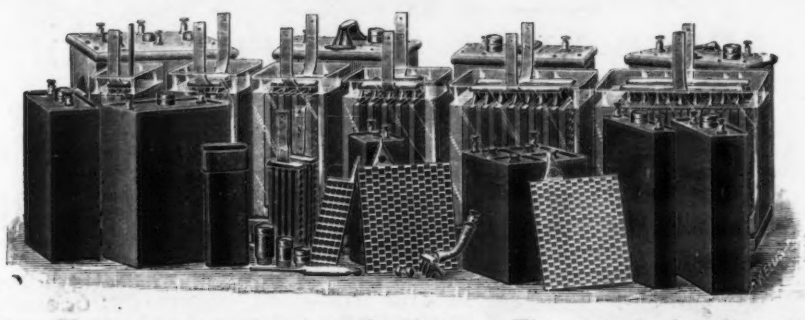

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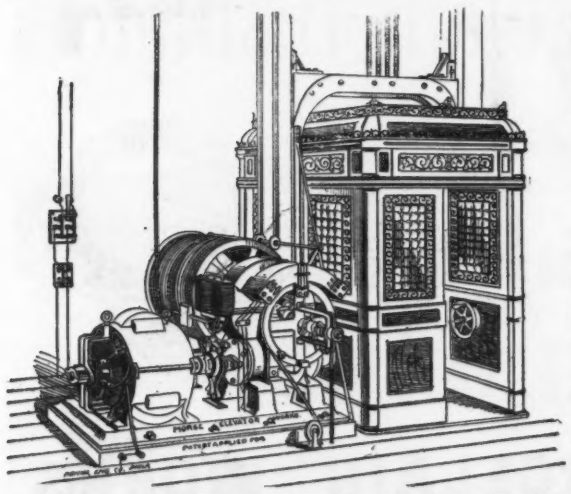

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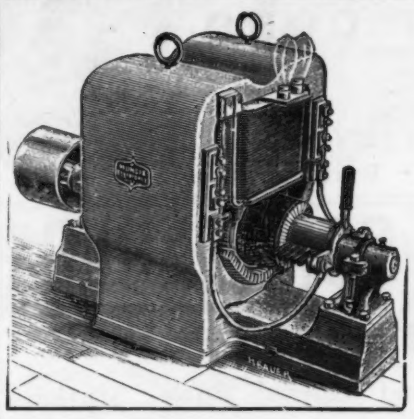

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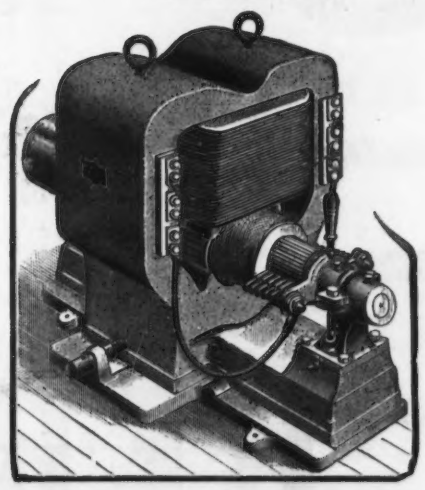

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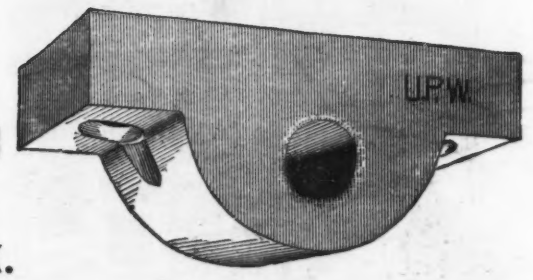


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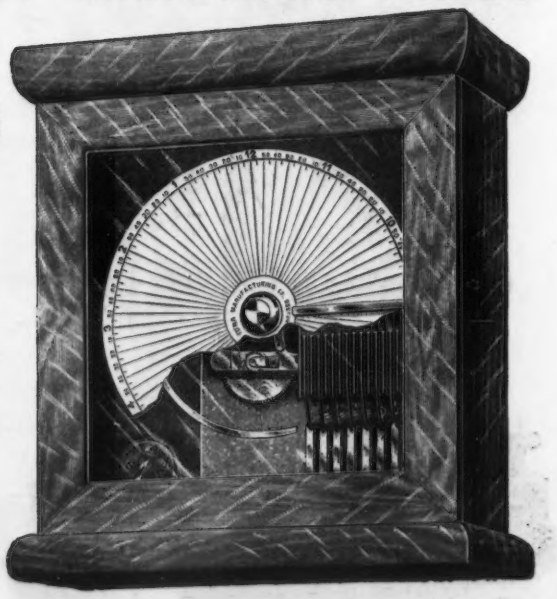

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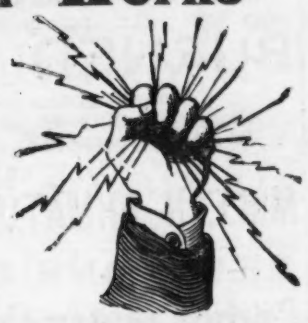

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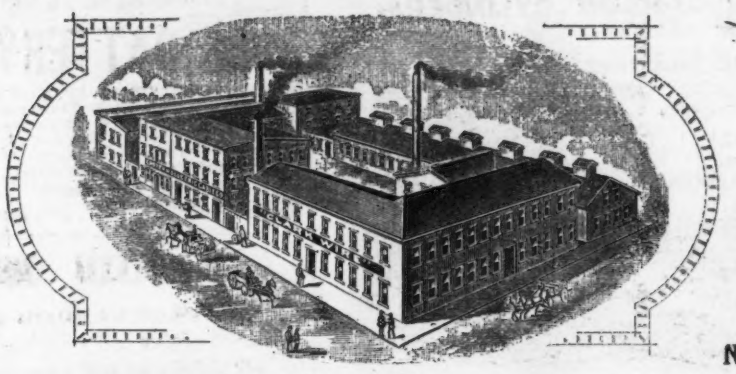

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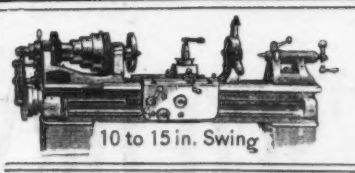

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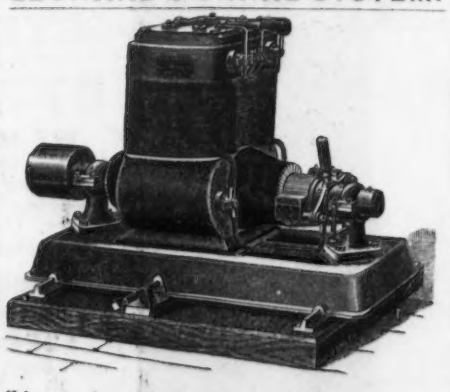

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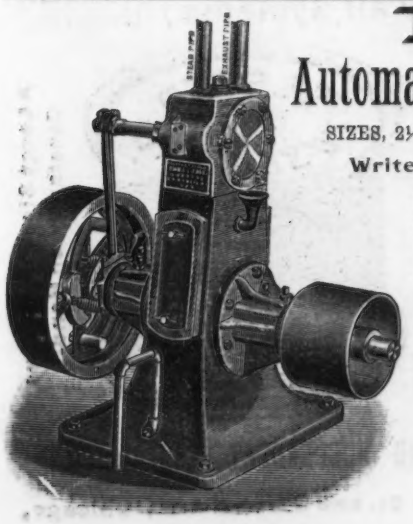

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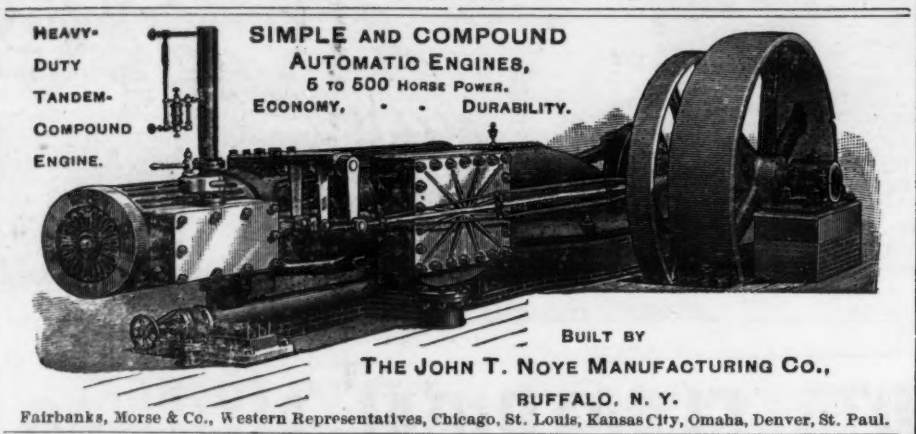

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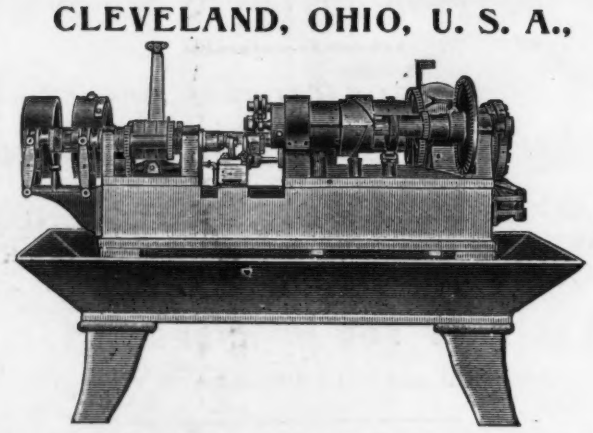

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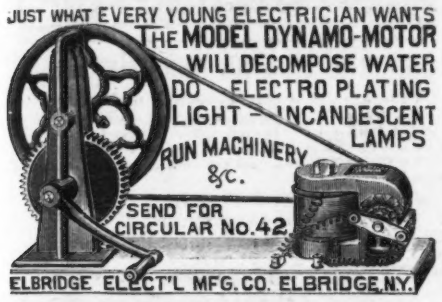


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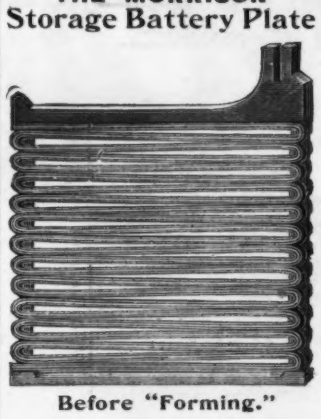

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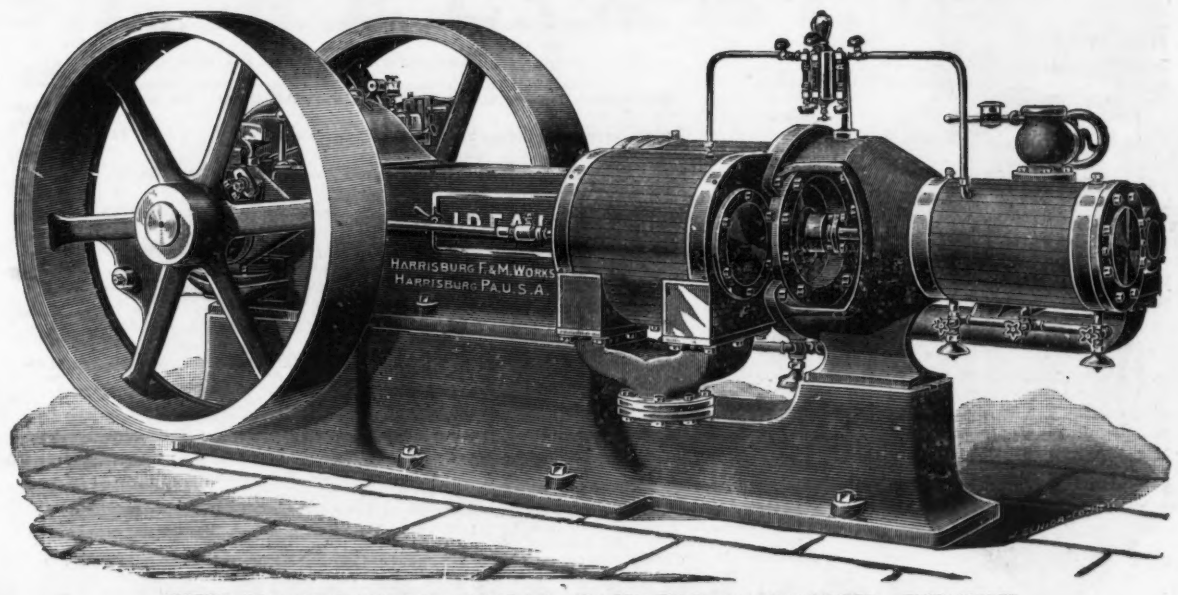


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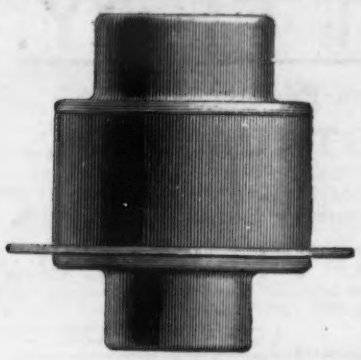

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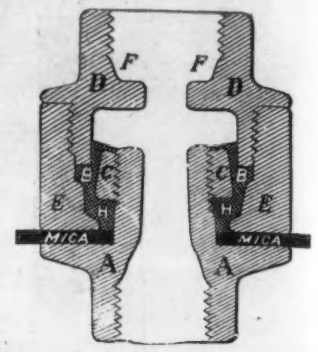


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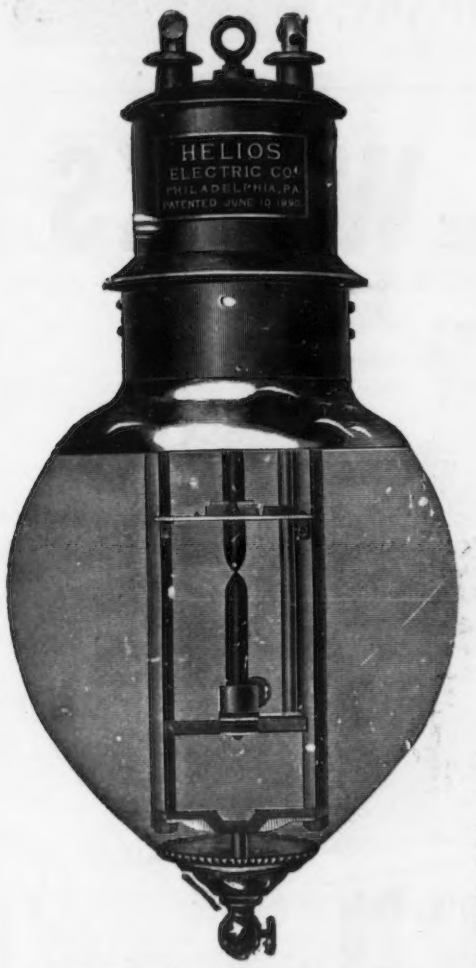


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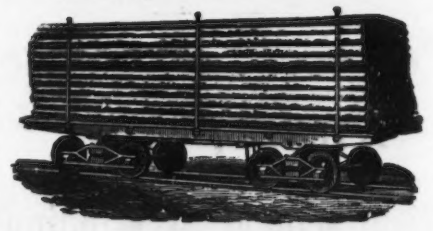

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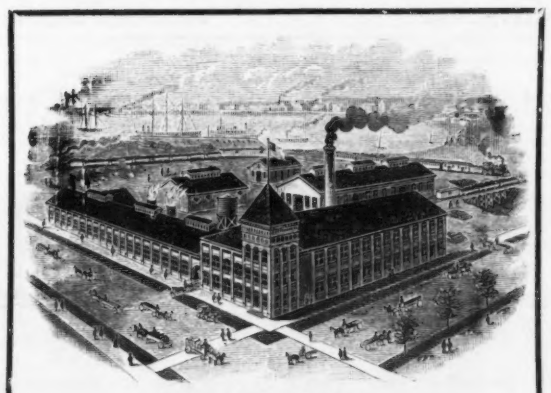
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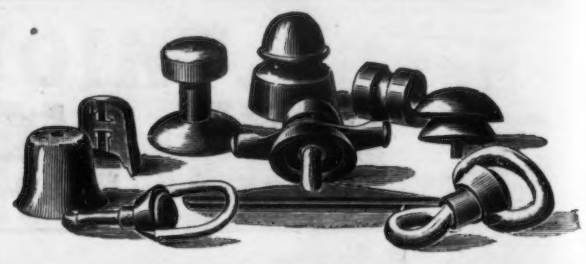

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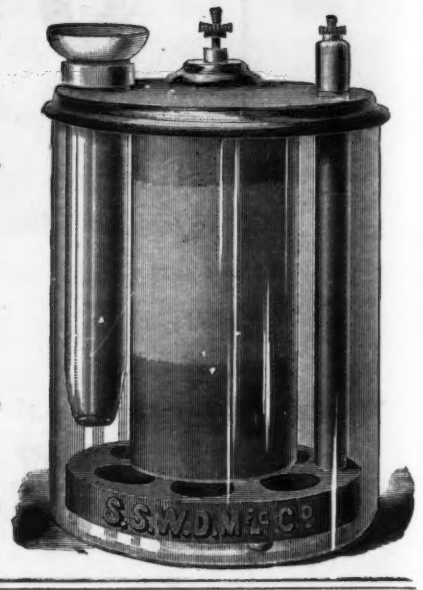


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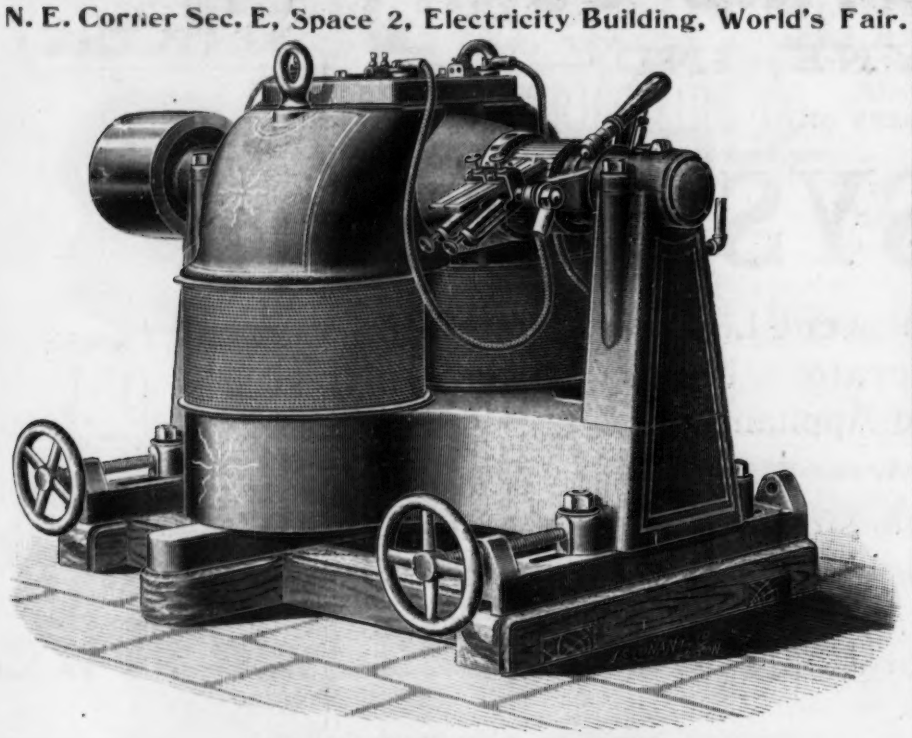

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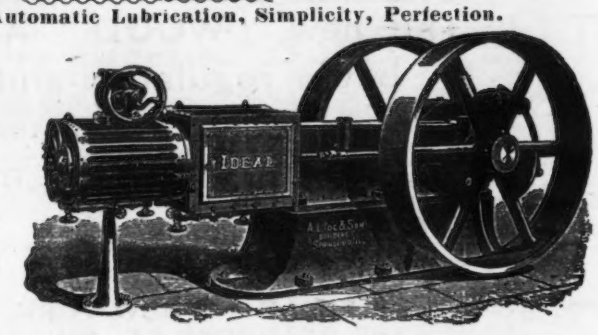


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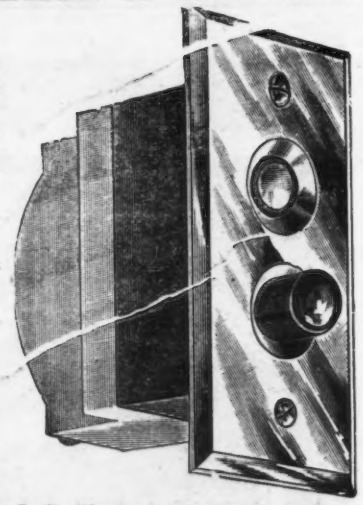

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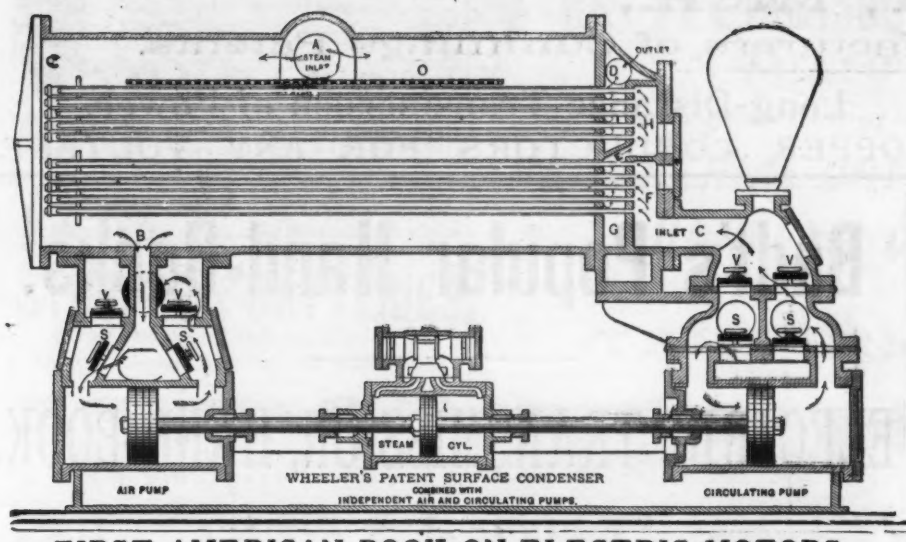

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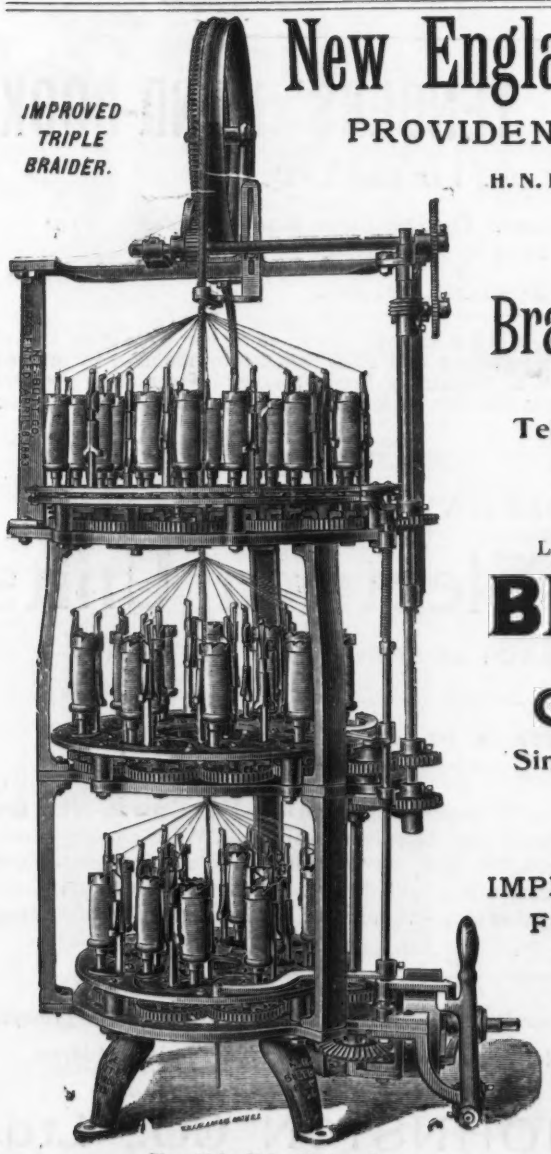

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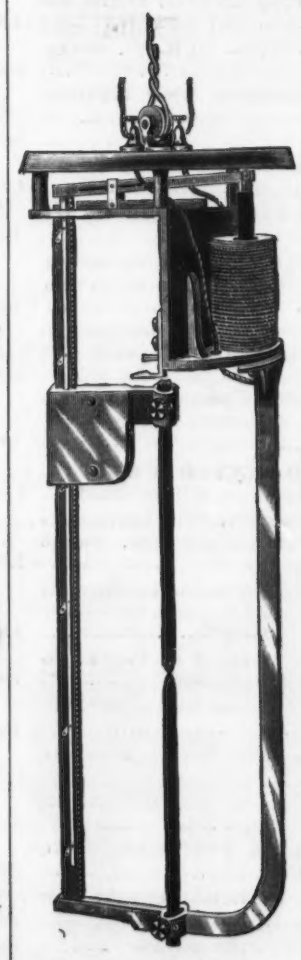

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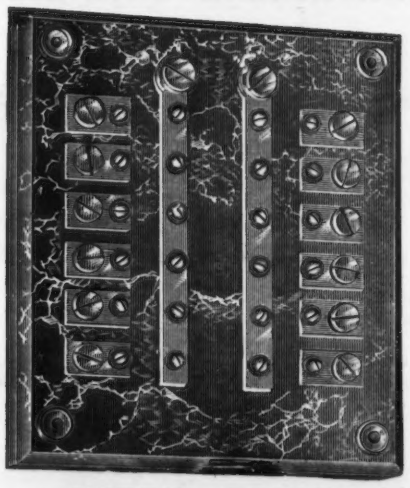
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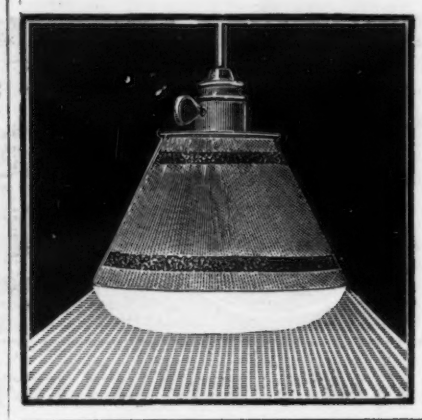
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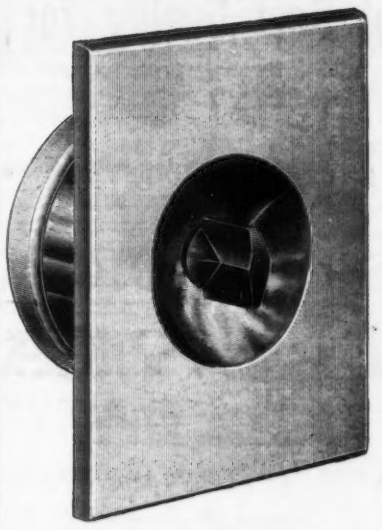
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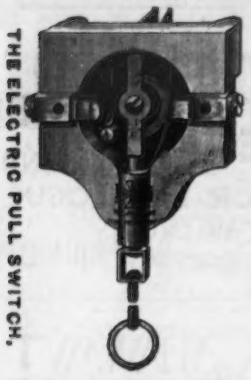
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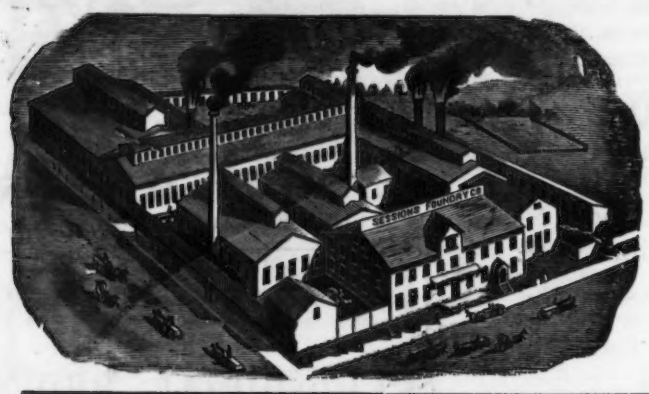


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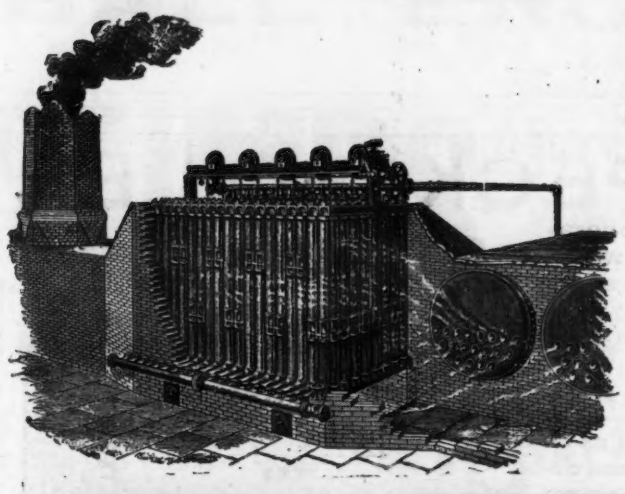

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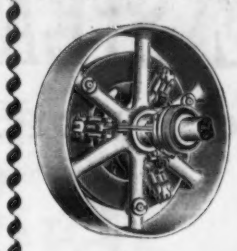

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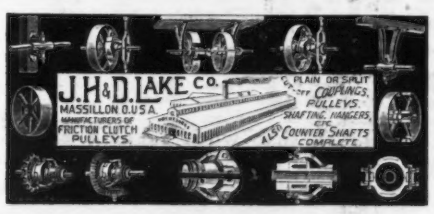


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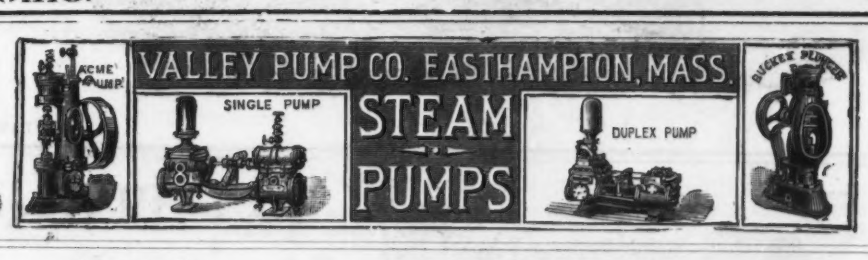

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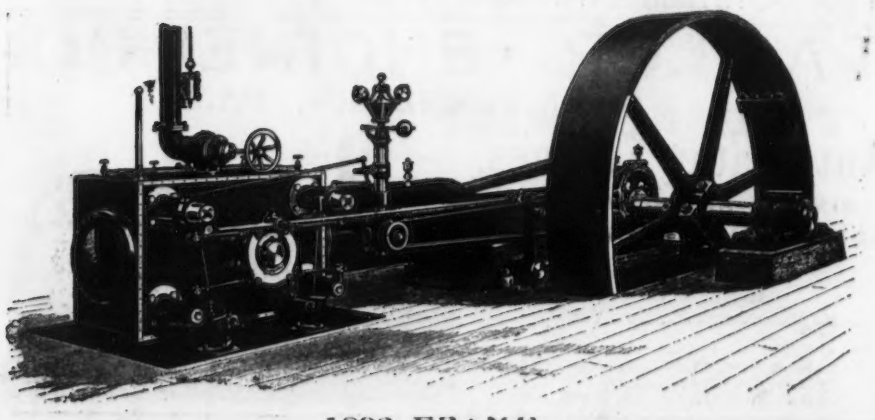

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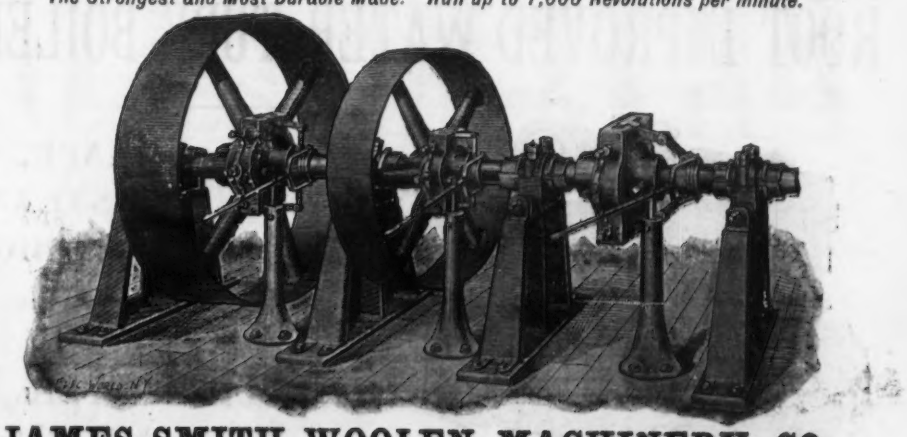

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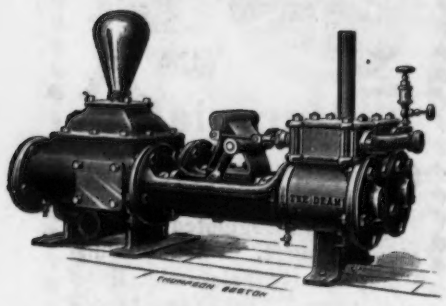

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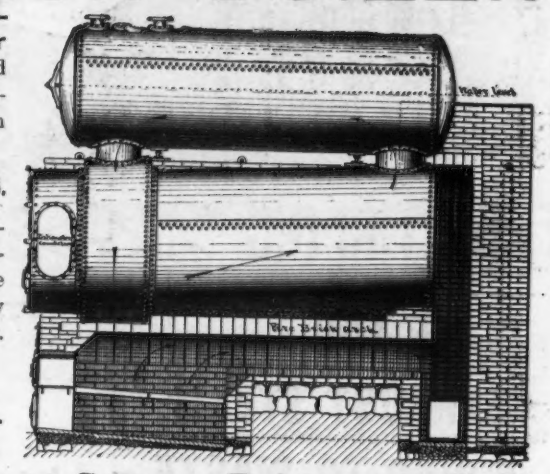

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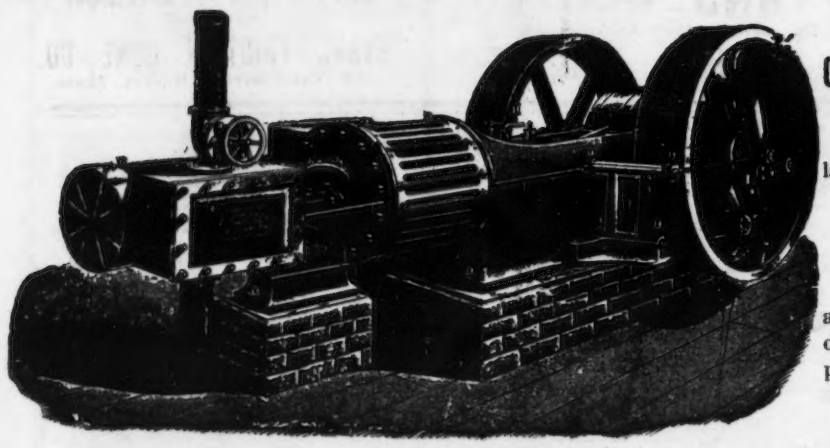

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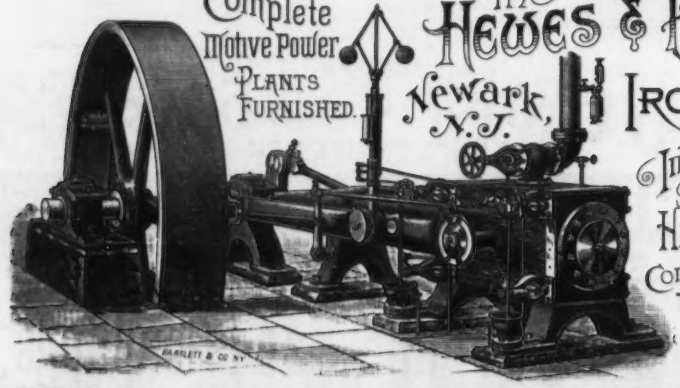

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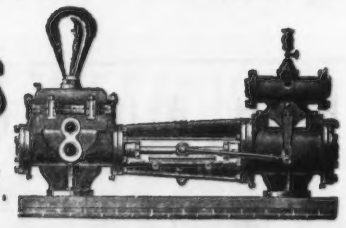

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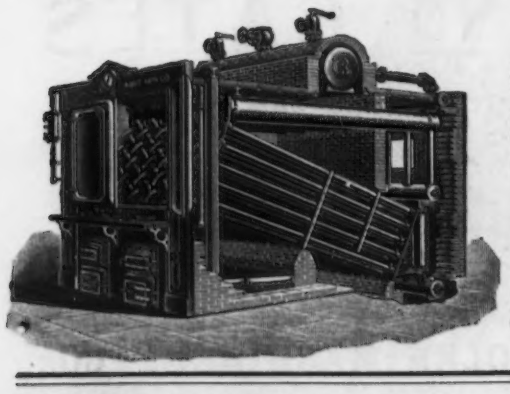

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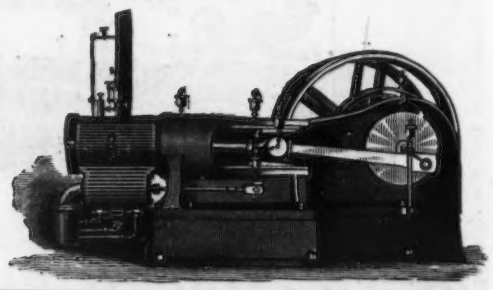

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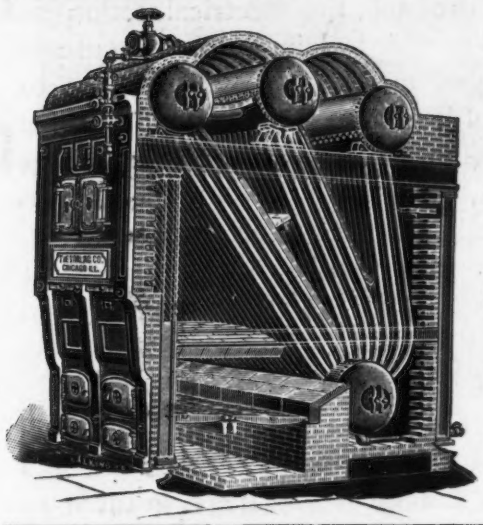

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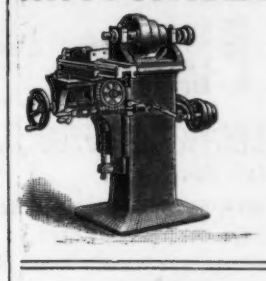

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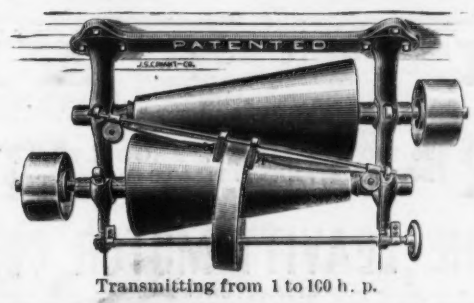


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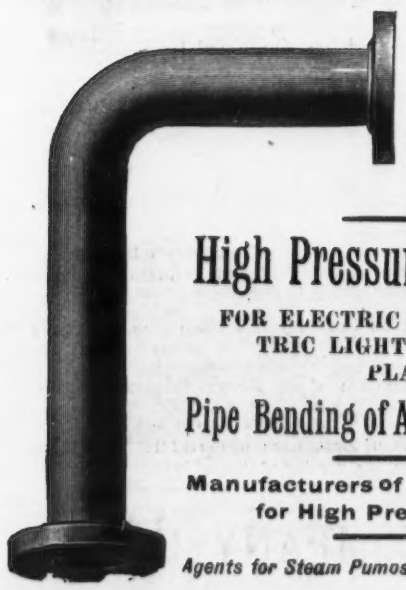

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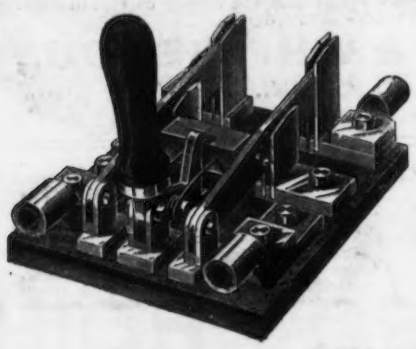

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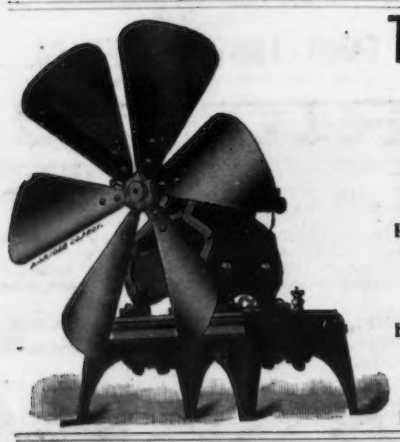

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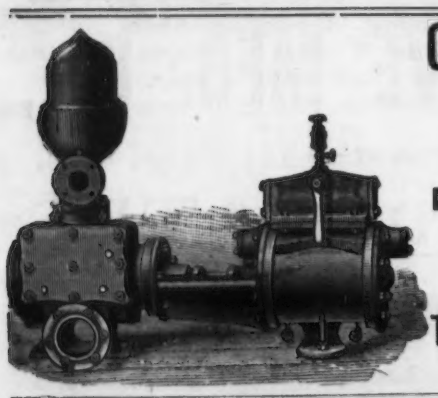

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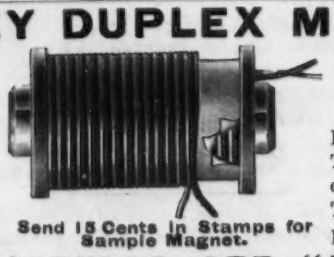

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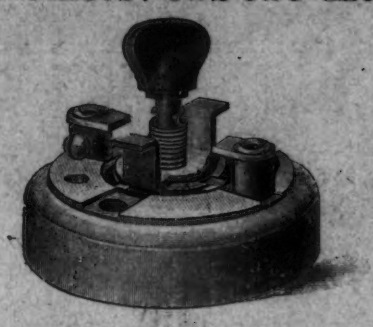

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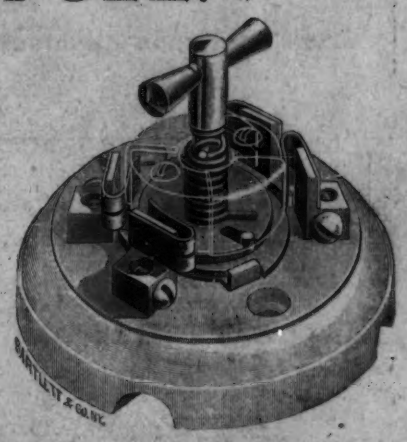


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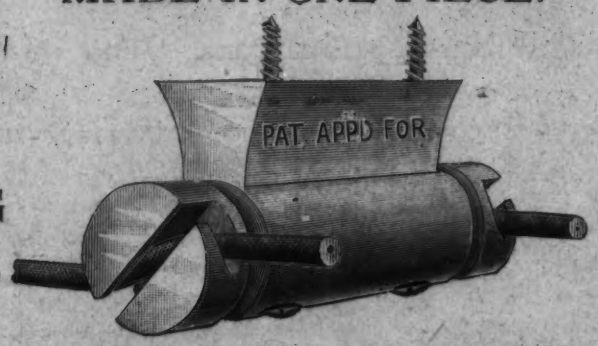


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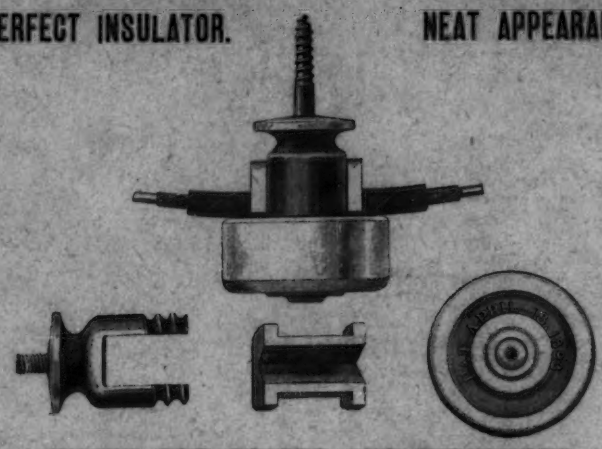

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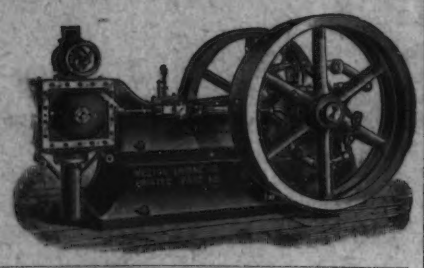

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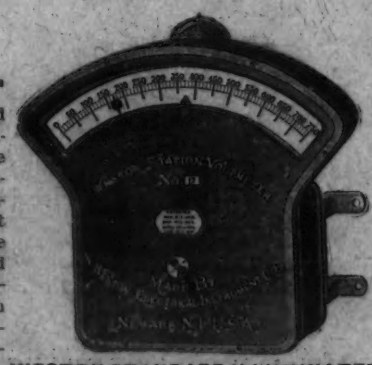

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